ALASKA

VOLUME IV

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GILBO

MT. PAVLOF, ALASKA PENINSULA

HARRIMAN ALASKA EXPEDITION
WITH COOPERATION OF WASHINGTON ACADEMY OF SCIENCES

ALASKA

VOLUME IV

GEOLOGY AND PALEONTOLOGY

BY B. K. EMERSON, CHARLES PALACHE
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AND F. H. KNOWLTON

H·A·E

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PREFACE

The present volume, the fourth of the Harriman Alaska Expedition series, contains papers on Geology and Paleontology. The Glaciers were treated in volume III. Study of the fossils brought back by the Expedition has resulted in the discovery of 38 new species and 7 new genera, of which 2 genera and 19 species are invertebrates, and 5 genera and 19 species plants.

Acknowledgments are due the authors of the several papers for the time and labor they have given the subjects entrusted to them. Of these authors, Dr. Dall, Professor Emerson, and Dr. Palache were members of the Expedition. Dr. Ulrich and Dr. Knowlton were not on the Expedition, but have kindly prepared the reports relating to the groups on which they are leading authorities. Acknowledgments are due also to the United States Geological Survey and the United States Biological Survey for the use of photographic material for illustrations.

The editor wishes to express his appreciation of the chapter headpieces, which add so much to the attractive appearance of the volume. The one at the head of the chapter on Fossil Plants was drawn by Mr. F. A. Walpole; all of the others by Mrs. Louise M. Keeler.

Mr. G. K. Gilbert has kindly relieved me of the editorial work necessary in preparing the illustrations and text of this volume for the press, and has written the Introduction, for which services he has my sincere thanks.

C. Hart Merriam,
Editor.

Washington, D. C.
May 1, 1903.

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GEOLOGY AND PALEONTOLOGY

INTRODUCTION

BY GROVE KARL GILBERT

THE papers in this volume represent the results in geology and paleontology of the Harriman Alaska Expedition. The narrative of the Expedition and an account of its organization are given in the first volume of the series, but as not all readers may have access to the entire series, a certain amount of repetition may be permitted in this place.

The Expedition occupied the months of June and July, 1899. Organized by Mr. E. H. Harriman, of New York City, and conducted at his expense, it was originally planned as a holiday excursion for his family and a few friends interested chiefly in hunting. The plan was afterward enlarged so as to include scientific work, and was further modified by giving the research corps practical control of the route and other details affecting their work. There were twenty-five scientific workers, representing a wide range of subjects — ethnology, zoology, botany, geology and geography. Five were accounted members of the geologic division, of whom three gave exclusive attention to geology and physical geography, while the others were partly occupied also with studies in ethnology and botany. The geologists were Dr. Wm. H. Dall, of the Smithsonian Institution and the United States Geological Survey, Mr.

John Muir, of Martinez, California, Professor Benjamin K. Emerson, of Amherst, Massachusetts, Dr. Charles Palache, of the geologic staff of Harvard University, and Mr. G. K. Gilbert, of the United States Geological Survey. Before reaching the field of active work they arranged a division of labor, so that each might give principal attention to some special subject, with a view to ultimate publication. Dr. Dall, already the foremost authority on the physical geography, paleontology, ethnology and resources of Alaska, took charge of paleontologic work; Mr. Muir, already distinguished as an explorer of Alaska glaciers, continued his studies of their general distribution and broader features; Mr. Gilbert also gave principal attention to glaciers, but studied especially their variation in size and the features bearing on the interpretation of Pleistocene glaciation in the eastern United States; Professor Emerson and Dr. Palache undertook the observation of the sedimentary, igneous and metamorphic rocks.

The opportunities for geologic work were conditioned by the mode of travel, the route, and the distribution and duration of the various stops. The Expedition was essentially a voyage, much the greater part of the two months being spent on the ship and in motion. But the time thus spent was not wasted. With unimportant exception we were continually in sight of land, and the physiographic expression of the country was the subject of nearly constant study. Brief landings were made almost daily, and in regions of special interest the vessel lingered for periods of several days, while excursions were made in launches and rowboats to various parts of the coast. On such occasions the ship remained the principal base of operations, but small parties operated independently with the aid of camping outfits. In a number of instances local studies were prolonged by leaving parties, either in camp

or at settlements, to be picked up when the ship afterward returned to the vicinity. Working time was somewhat restricted by foggy and rainy weather, but the season fortunately proved to be an exceptionally open one for that region, and the loss through fog was perhaps more than compensated by the great length of the subarctic summer day. The scientific interests of the Expedition were so varied that not all could be satisfied in the selection of stopping places, and the limitations thus imposed were felt by all the investigators. But the geologists had much occasion for congratulation in this regard. Glaciers, by reason of their beauty, were attractive to the entire company, and their popularity was an important factor in determining details of route. From the points of view of the stratigrapher, the petrographer, and the paleontologist, the selection of landing points was practically at random, but this was less to be regretted because intelligent selection was almost impossible in a region so little known, and almost every locality afforded something of novelty and interest.

Those who in the future shall have occasion to use these reports will be aided, in judging of our opportunities and the limitations thereto, by a systematic account of our route, our landings, and the occasional doubling of the line of geologic observation by the organization of branch parties.

Itinerary.—The general features of our route are shown by the map, plate I. Starting from Seattle, Washington, May 31, we followed the 'inside passage' among the islands of British Columbia and southern Alaska to Skagway, at the head of Lynn Canal. Several hours were spent at Victoria, British Columbia (June 1), on Annette Island (June 4), at Wrangell (June 4–5), and at Juneau and Douglas (June 6). There were brief landings on Malcomb Island. British Columbia (June 2), on Princess

Royal Island and at Lowe Inlet, British Columbia (June 3), and at Farragut Bay, Alaska (June 5). From Skagway we made an excursion by rail to White Pass (June 7), and then steamed to Glacier Bay (June 8) by way of Juneau. Palache remained at Juneau and Douglas from June 6 to June 8, examining the Alaska-Treadwell mine and visiting the canyon back of Juneau. We remained in Glacier Bay five days, with headquarters near Muir Glacier. Muir, Palache, and Gilbert spent three days (June 10–13), with boat and camping outfit, in Hugh Miller, Reid, and Geikie inlets. Sitka was reached June 14, by way of Peril Strait, and was our headquarters for four days. Emerson and Gilbert accompanied an excursion down the coast to Hot Springs; Gilbert ascended Verstovia, a small mountain back of the town; and Palache visited Silver Bay.

From Sitka we followed the coast westward, touching at La Perouse Glacier (June 18), and giving several days each to Yakutat Bay (June 18–23) and Prince William Sound (June 24–29). Within Yakutat Bay we landed at the winter and summer villages of the Indians, and steamed to the head of Russell Fiord. Muir and Gilbert followed Nunatak Fiord to Nunatak Glacier, and afterward visited Hubbard Glacier, Osier Island and the adjacent mainland, where a camp was made, and Haenke Island. Gilbert visited Hidden Glacier, and Emerson a neighboring point of land. Palache spent several days with a shore party on the west coast of the bay, making an excursion to the mountains at the north.

The first landing in Prince William Sound was at Orca. Afterward the ship entered Columbia Bay and left a camping party, including Gilbert and Palache. Then it visited College Fiord, where a landing was made at Bryn Mawr Glacier, and Harriman Fiord, where a second camping party, including Muir, was left. Orca was again visited,

and the shore parties were then picked up. The shore work in Columbia Bay, chiefly on Columbia Glacier, occupied three days (June 25–28); that in Harriman Fiord three days (June 27–29). The ship touched also at copper prospects on Landlocked Bay, Virginia Bay and Latouche Island.

Continuing westward (June 30) the vessel touched at Homer, and at night left a shore party in Kukak Bay, on Alaska Peninsula. This party contained no geologist, but one of its members, Mr. Saunders, made a valuable collection of fossil plants. The following morning a hunting party was left in Uyak Bay, Kadiak Island, and the vessel then proceeded to Kadiak village, where it remained four days. During this period there was much exploration of the vicinity. Palache made an excursion up English Bay, and Emerson visited Woody Island. The parties left at Kukak and Uyak bays were then picked up, and the westward course was resumed. The next stop (July 7) was at Popof Island, one of the Shumagin group, where a collecting party was left, and Palache availed himself of this opportunity for effective shore work. We then continued westward to Dutch Harbor (July 8), and turned northward across Bering Sea. A very brief landing was made the same day on Bogoslof Island; some hours were spent (July 9) on St. Paul Island; the coast of Plover Bay, Siberia, was visited (July 11); and landings were made on the great spit and the mainland at Port Clarence (July 12). Returning southward, we touched at St. Lawrence Island (July 13), gave several hours each to Hall and St. Matthew islands (July 14 and 15), and reached Dutch Harbor July 17.

Continuing thence the homeward voyage, we touched at Popof Island (July 18), to pick up the party left there eleven days earlier, and the same evening sent a launch to the mainland for Palache. During our absence Palache

had visited various parts of Popof and Unga islands, and spent a week on Alaska Peninsula in the vicinity of Chichagof Cove, Stepovak Bay. After a brief landing on the northwest coast of Kadiak Island, we reached Kadiak village on the morning of July 20, and the following day made an excursion by launch to Long Island. On the twenty-first of July we reached Homer, whence the main party made an excursion up Cook Inlet, while Dall, Gilbert, and Palache visited Halibut Cove and Grewingk Glacier. On the twenty-third we touched at Yakutat, on the twenty-fifth at Juneau. Our last halt (July 26–27) was made at Cape Fox, near the southern boundary of Alaska, and we reached Seattle early on the morning of the thirtieth.

Results. — The geologic field work of the Expedition may properly be characterized as a reconnaissance; and in this respect it resembles the greater part of the work which had previously been accomplished in the same region. While it was in progress there was much active exploration in the interior of the Territory, chiefly by members of the United States Geological Survey, and that work has continued in later years. The Geological Survey has also done a certain amount of systematic surveying, so that a beginning has been made in the definite mapping of Alaska geology. The area of the Territory is so vast and the workers are so few, that for many years broad generalizations can be reached only by the patching together of widely scattered items of local information; and to the body of this local information the work of the Expedition makes a number of contributions.

The results in glacial geology have already been published, partly by Muir, in volume I, partly by Gilbert, in volume III. Muir's paper is a general statement of the extent and distribution of Alaska glaciers, brought down to date by the inclusion of the observations of the Expedi-

tion. Volume III goes into greater detail, comparing the condition of glaciers in 1899 with their condition as previously observed, so as to infer changes, and making systematic records of the positions of ice fronts, in order to facilitate future comparisons. It treats also of features tending to throw light on problems of Pleistocene glaciation in the eastern United States, discusses the Pleistocene glaciation of Alaska, and incidentally makes a contribution to earlier geologic history by describing certain peneplains belonging to the pre-Pleistocene topography.

A noteworthy result in stratigraphic geology is the correlation, on fossil evidence, of slates and shales in three widely separated localities — Yakutat Bay, Prince William Sound, and Kadiak Island — and the determination of their age as early Jurassic. The formation or series thus constituted — named Yakutat by Russell — covers large areas, is elaborately and intricately folded, and is the dominant constituent of mountain masses which have a long history, including base-leveling and subsequent uplift and dissection.

The Alaska Peninsula, which so bristles with volcanic peaks as to appear from a distance characteristically igneous, was found, at a point where narrowed by opposing bays, to contain a ridge of uplifted marine strata of Eocene age. These strata contain a molluscan fauna, the first of that age discovered in Alaska, and show also, by their physical constitution, that the region was already the scene of volcanic activity in early Tertiary time. A collection of Eocene plants was also obtained from another point on the coast of the peninsula.

The paleontologic collections include a number of new species, thirty-eight of which are described in this volume. Twelve are Jurassic and the remainder Eocene. Of the Jurassic species seven were found to be so peculiar as to require the erection of new genera.

LIST OF NEW GENERA AND SPECIES

(The new genera are indicated by Italics)

INVERTEBRATES

? Callocardia kincaidii Dall.
Crepidula precursor Dall.
Crepidula ungana Dall.
Dosinia ? alaskana Dall.
***Inoceramya* concentrica Ulrich.**
Macrocallista gilberti Dall.
Margarites peninsularis Dall.
Mesodesma alaskensis Dall.
Modiolus alaskanus Dall.
Modiolus harrimani Dall
Papyridea harrimani Dall.
Protothaca grewingkii Dall.
Saxidomus popofianus Dall.
Spisula callistiformis Dall.
***Terebellina* palachei Ulrich.**
Trochita alaskana Dall.
Yoldia breweri Dall.
Yoldia emersoni Dall.
Yoldia palachei Dall.

PLANTS

Æsculus arctica Knowlton.
***Arthrodendron* diffusum Ulrich.**
Cancellophycus rhombicum Ulrich.
Corylus harrimani Knowlton.
Corylus ? palachei Knowlton.
***Gilbertina* spiralis Ulrich.**
***Gyrodendron* emersoni Ulrich.**
Helminthoida abnormis Ulrich.
Helminthoida exacta Ulrich.
Helminthoida subcrassa Ulrich.
Helminthoida vaga Ulrich.
Hicoria magnifica Knowlton.
***Myelophycus* curvatum Ulrich.**
Phyllites saundersi Knowlton.
Picea harrimani Knowlton.
Pterospermites alaskana Knowlton.
Pterospermites magnifolia Knowlton.
***Retiphycus* hexagonale Ulrich.**
Vaccinium alaskanum Knowlton.

All specimens of rocks and fossils either have been, or are to be, deposited for permanent preservation in the National Museum at Washington.

GENERAL GEOLOGY

GENERAL GEOLOGY

NOTES ON THE STRATIGRAPHY AND IGNEOUS ROCKS

BY BENJAMIN KENDALL EMERSON

WITH PETROGRAPHIC NOTES BY CHARLES PALACHE

INTRODUCTION

Stratigraphical geology and petrography form the subject of this chapter. The plan of the expedition, giving only rare opportunities for long stops or inland excursions, was not so favorable for studies in this field as for work in many other departments of science. It was rather our fortune to enjoy the geology with the scenery of the remarkable regions we were visiting, and to contribute through our geological enthusiasm to the pleasure and interest of the party as a whole, than to bring away much that was new to our science.

It was greatly to our advantage that we had with us Dr. Dall, who knew more of the paleontology, zoology, geology and hydrography of the coastwise regions of Alaska and Bering Sea than any other person, and Mr. Gilbert, whose knowledge of the geology of the western half of the continent is so especially full. Mr. Palache

brought from the scene of his earlier studies in California an accurate knowledge of the coastal formations of the Pacific slope. The remaining member of the geological corps had traversed the continent by various routes and had studied in India, Malacca, Japan, and the Sandwich Islands, and thus was able to appreciate the general geological relations of the countries visited, and especially to study the volcanic rocks.

Mr. Palache omitted part of the route of the Expedition in order to examine more carefully the Alaska-Treadwell mine, and gave up the trip across Bering Sea that he might make local studies in the Shumagin Islands and about Chichagof Cove on the Alaska Peninsula. The results of his studies of these localities are reported in two papers following the present, and he has also contributed a short paper on the minerals collected. His other field observations were reported to me, and are incorporated in the following pages. In the office study of our material he has cooperated by assuming an important share of the petrographic work, and many of the rock descriptions are from his pen.

In our railway journeys across the continent, both outward and return, we saw much of value to the geologist, but there was peculiar interest in the side trips to the Dalles of Snake River and Shoshone Falls. In the one we steamed swiftly for half a day between steep or even vertical walls made up of many superposed tuff beds and lava flows, often with the most perfect columnar structure; and in the other we drove for many miles over the surface of lava flows that seemed to have cooled only recently. The ropy lava, the small craters, the great pustules which had been inflated on the surface of the liquid mass and then congealed and collapsed, are plainly parts of an enormous and very recent lava flow. This is divided by the river canyon, in whose vertical walls we saw other lava

beds, tier upon tier, telling of earlier flows. From one of these the river plunges 250 feet to the bottom of its deeper gorge. Except in great floods, the volume of the river is less than that of Niagara, but its greater height and the grandeur of its surroundings make this the most impressive waterfall in America.

Around Seattle, and as we sailed northward through the straits, we saw grand sections of the extensive Pleistocene deposits so fully described by Mr. Bailey Willis, and then began to enter regions less fully explored.

VICTORIA TO UNALASKA

BRITISH COLUMBIA

Our first landing north of Victoria was at Beaver Cove, on the east side of Vancouver Island. The local geology has been described in brief by Dawson,[1] who notes that parts of both shores of the cove are occupied by grey and reddish granite, the remainder by compact greenish grey feldspathic rocks. On his geological map the granite of this place is shown as a small outlier of an extensive mass to the east and north, surrounded by dark, metamorphosed, basic volcanic rocks.

We found the country rock to be a dark green diorite (3),[2] tough and fine-grained, clearly representing the Vancouver Series. The diorite is cut in many directions by dikes of varying character, from less than a foot to about three feet in width. Most of them consist of light to dark grey feldspathic porphyries, which on microscopic examination proved to be quartz-diorite-porphyry (2 and 5), with the exception of one which is augite-diorite-porphyry (4). Some of the very narrow dikes are of a grani-

[1] Ann. Rep. Geol. and Nat. Hist. Survey Canada, vol. II, p. 56B. 1886.

[2] The rock specimens collected by the Expedition are numbered consecutively. When a thin section was made, the slide received the same number as the specimen. The numbers in parenthesis in the text usually refer to thin sections, but may refer to hand specimens or to both sections or specimens. See also page 8.

toid rock, which was seen to widen out to the eastward, on the point of the cove, into a considerable mass. This proved to be a biotite-tonalite (1), rather coarse and granitoid in texture and rich in titanite, a very characteristic rock for this whole region.

About 200 miles north of Beaver Cove we touched at a waterfall on the eastern shore of Princess Royal Island, near the northern end of Fraser Reach, and found the same uniform-textured biotite-tonalite, containing some hornblende and a notable amount of honey-yellow titanite in sharp crystals. This rock apparently constitutes both shores of the channel the whole length of Fraser Reach

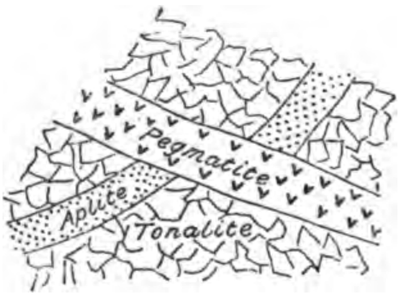


FIG. 1. DIKES, LOWE INLET, B. C.

and the upper two-thirds at least of Graham Reach, a distance of about 40 miles. It was found again on the mainland in Lowe Inlet, a branch of Grenville Channel, 50 miles farther north, where we next landed. The tonalite (7 and 10) is here somewhat coarser and less homogeneous. Its principal feldspar is a basic oligoclase, beautifully zoned, and twinned on the albite and Carlsbad laws. There is very little orthoclase or quartz. Biotite is abundant, and some sharply idiomorphic green hornblende is present. Apatite, zircon, titanite and epidote (apparently original) were observed as accessories. The rock is here extremely fresh, and is lighter colored than at points previously visited.

It contains, where seen by Mr. Palache, rather abundant inclusions or segregations, which are dark in color, banded or schistose, and porphyritic with quartz and feldspar crystals. It is cut by dikes of pegmatite and aplite. In one case the aplite is cut by pegmatite (fig. 1), in another the pegmatite is cut by aplite (fig. 2). The aplite (12), in addition to quartz, orthoclase, and a little plagioclase feldspar, contains minute garnets and isolated octahedra of magnetite. Veins of alteration containing epidote were noted.

These granitoid rocks continued on north through Grenville Channel and Chatham Sound. At the deserted Indian village on Cape Fox, west of Duke Island, we found

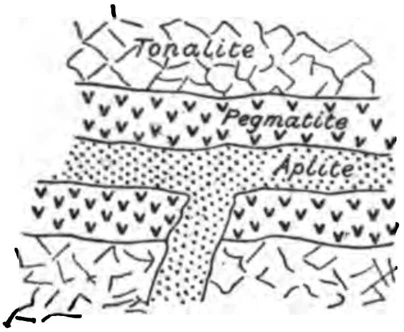


FIG. 2. DIKES, LOWE INLET, B. C.

monotonous old-looking gneisses, quartzites, and coarse hornblende- and mica-schists, much tilted.

Just across the straits at the Indian village of New Metlakatla, on Annette Island, we made the following section along the coast from the town west to the cliffs and cascade:

1. Highly inclined schistose rocks, often chloritic, with frequent interbedded bands of what appeared to be highly altered sandstone.

2. A considerable thickness of a much veined and jointed greenstone, probably an altered intrusive.

3. The cliff near the Cascade and probably the whole neighboring mountain is of yellowish arkose, much brecciated, and veined with flint.

On the beach were boulders of granite, vein-quartz, amphibolite, hornblende-gabbro, diabase, etc.

Under the microscope the rocks of this section were found to be as follows:

1. Schists. Quartz-zoisite-schist (47). An extremely fine quartz mosaic, with parallel structure produced by sericite and biotite plates. Very abundant grains and laths of zoisite, some epidote, and titanite surrounding ilmenite. Quartz-epidote-schist (41). Much the same as the last, but with more epidote than zoisite, and chlorite as well as sericite.

These rocks may well be altered sediments, but the recrystallization is complete and their original character not certain.

2. Greenstone (45 and 46). Amphibolite. A fine-grained aggregate of hornblende needles, plates of chlorite and sericite, and grains of quartz and epidote, with some zoisite. A slight appearance of coarse porphyritic structure, as though feldspar phenocrysts had been present in the original rock. Probably derived from a diorite-porphyry, or similar igneous rock.

3. Arkose (44). An aggregate of angular fragments of quartz, orthoclase, and plagioclase, cemented with granular quartz, limonite and pyrite. All the larger fragments show pronounced cataclastic structure and wavy extinctions.

WRANGELL AND NORTHWARD

At Wrangell the hill north of the town presents the following section (fig. 3):

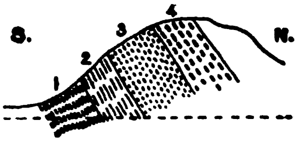


FIG. 3. SECTION NORTH OF WRANGELL, ALASKA.

1. Soft blue slate.
2. Hard blue slate, with sandy and micaceous layers.
3. Coarse granitoid metamorphic sandstone (arkose).
4. Very siliceous biotitic sandstone.

These rocks, which in the field present the appearance of but slightly metamorphosed sedimentaries, give surprising results when studied under the microscope. They prove to be highly feldspathic and almost entirely recrys-

tallized, so that nearly all traces of sedimentary origin are lost.

No. 2 (29) shows a fine granular groundmass, largely of quartz but with some feldspar, scattered through which, without parallelism, are abundant scales of biotite. Magnetite in fine grains and opaque carbonaceous matter are also present. The quartz grains retain their clastic character fairly distinctly.

No. 3 (30) would be called from the thin section alone a granitoid gneiss. It is a hypidiomorphic-granular aggregate of quartz grains and sharply bounded, zoned crystals of plagioclase feldspar, the zones giving extinctions corresponding to acid labradorite at the centre and oligoclase at the boundaries. The feldspars are perfectly fresh, and in the centre free from inclusions, but their outer zones are filled with clastic grains which have been surrounded during the later growth of the crystals. Many of them have the appearance of clastic grains secondarily enlarged during the recrystallization of the rock, but this is not always evident. The interstices between the feldspars, which make up perhaps half of the rock, are filled partly with the granular quartz, partly with plates of biotite and grains of garnet and zoisite. No parallel structure is visible in the slide.

No. 4 (31) is similar to the last but appears more gneissoid, owing to the parallelism of the biotite plates. It also has more quartz and some muscovite.

The field evidence is conclusive as to the sedimentary origin of these rocks, and they offer a beautiful illustration of the formation of gneiss from a feldspathic sandstone.

The rocks of the last two localities probably belong to the Vancouver Series described below, page 42.

The celebrated garnet locality at the mouth of the Stikine River is about ten miles north of Wrangell and is probably in this same series. It was not visited, but it is said to be very extensive.

At Farragut Bay, Frederick Sound, the rock is a rather uniform schistose serpentine, very thin-bedded, much jointed, and in nearly vertical position. Quartz veins are abundant. In thin section (13) this rock was found to be a nearly pure fibrous serpentine, containing shattered frag-

ments of colorless augite crystals which in places are bordered by colorless secondary hornblende needles. No trace of feldspar could be found. The rock seems to have been derived from a pyroxenite consisting chiefly of diopside. The schistose character is produced by shearing along the most serpentinized bands, and the shattered condition of the remaining augite crystals is good evidence that such shearing has taken place.

A great variety of rocks were seen in the boulders on the shore, tonalites like those farther south, diorite, garnetiferous gneisses, etc.

At Juneau Mr. Palache remained for several days and made a special study of the Treadwell mine, upon which he makes a special report in this volume.

We saw at Sitka the first certain outcrops of the Vancouver Series, which we traced northward to Port Clarence by a small group of peculiar fossils, and which is made the subject of a separate chapter, page 42.

At various places in the vicinity of Sitka these sedimentary rocks are traversed by granitic dikes. The granite (58) is coarse granular to fine porphyritic in texture, and consists chiefly of quartz and orthoclase, with considerable acid oligoclase and sparing biotite, largely altered to chlorite. Both orthoclase and oligoclase are occasionally developed in porphyritic crystals with sharp boundaries.

Cutting the granite, near the Hot Springs, are several narrow dikes of a dark rock looking like diabase, but which, on examination with the microscope, proved to be a lamprophyre of the uncommon species spessartite, according to the definition of that rock by Rosenbusch. It is a compact, fine-grained rock (62) with panidiomorphic granular structure, consisting of minute interlaced prisms of brown hornblende and about equal amounts of twinned and untwinned feldspar with subordinate amounts of diop-

side and grains of epidote and titanite. The hornblende is in prisms, slender and very sharply bounded, showing pinacoids and often terminal planes also. It often encloses feldspar grains. It is generally very fresh, but occasionally shows alteration to chlorite. The feldspar showing albite twinning was proved by extinction and refraction to be oligoclase. The untwinned feldspar seemed to be of the same species, rather than orthoclase, which might be expected to occur in this rock. The diopside is frequently surrounded by chlorite, and has probably furnished most of that mineral, which is quite abundant in parts of the slides, and is the only decomposition product present. A slide cut across the contact with the granite (60) shows at the contact a band, 1 mm. wide, of apparently pure glass, and the spessartite quite uniformly grows coarser-grained away from the contact.

The hot waters of the springs, which have a temperature of about 150° F. and contain sulphur and carbonic acid, seem to rise through the granite, which is the nearest outcropping rock.

Dr. Dall visited Biorka Island, off Sitka Harbor, and found it to consist of a light-colored biotite tonalite, perhaps a phase of the Hot Springs granite. It is cut by a single large dike of rhyolite, which shows a pronounced parting into small columns. The thin section of this rock (51 and 52) shows a well-characterized flow structure, with abundant development of coarse spherulites along the lines of flow and about small scattered phenocrysts of quartz, oligoclase, and Carlsbad twins of orthoclase, the remainder of the groundmass being microgranular.

GLACIER BAY

In Glacier Bay a light-colored quartz-diorite or tonalite was found to be the principal rock on the west side, as already determined by Reid.[1] It is cut by innumerable

[1] Glacier Bay and its Glaciers, 16th Ann. Rep. U. S. Geol. Survey, Part 1 p. 433. 1896.

dikes of various basic igneous rocks. In places it has picked up large fragments of the limestone that occurs in mass near at hand. It has contorted and twisted the bedding very much, and has formed contact minerals (essonite, pyroxene) in the limestone at the border.

On the nunatak at the eastern front of Hugh Miller Glacier the tonalite is cut by a diorite dike which contains a great horse of the tonalite and is itself cut and shifted by a later aplite dike (fig. 4).

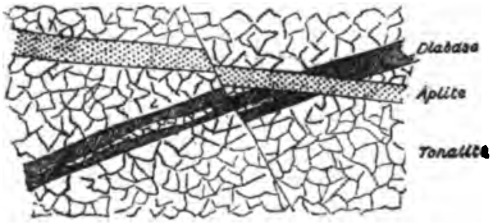


FIG. 4. DIKES IN GLACIER BAY.

The limestone is determined as Carboniferous by Professor H. S. Williams, on the evidence of a single specimen of Lonsdalia, and the tonalite must be younger, as it penetrates and alters this. It resembles closely the tonalite of Plover Bay, Siberia, and St. Lawrence Island, described below; and on St. Lawrence Island similar limestones and contact deposits are also found.

The only point where observations were made which added to the information contained in Reid and Cushing's map[1] was at the small glacier discharging into Reid Inlet next west of the Hugh Miller Glacier and named by the party Reid Glacier. This glacier was visited by Messrs. Gilbert and Palache, and the rocks on either side of its front were studied.

The point on the east side is made up of coarsely crystalline white marble, which is cut by a network of igneous dikes (plate II).

[1] 16th Ann. Rept. U. S. Geol. Survey, part I, plate xc. 1896.

EXPLANATION OF PLATE II

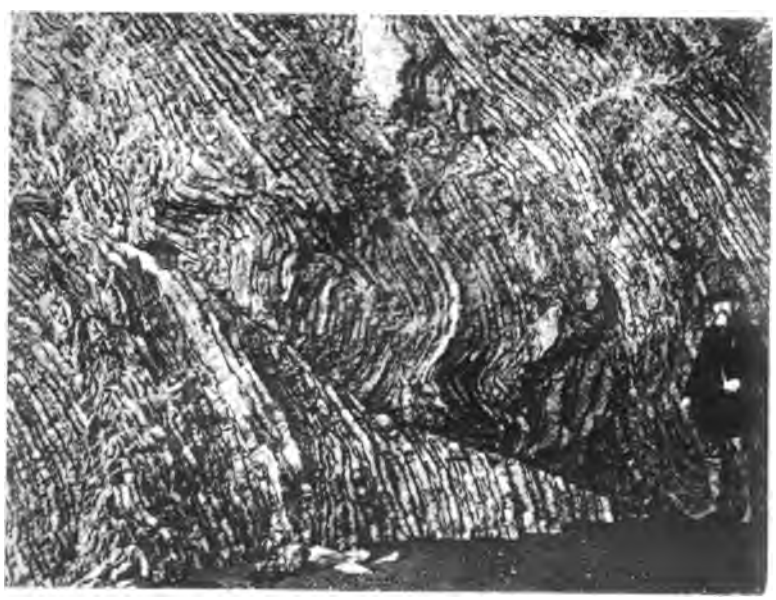
Upper Figure. — Dikes in Marble

The locality is on the west side of Reid Inlet, Glacier Bay, between Hugh Miller and Reid glaciers. The cliff is glaciated, and has been so recently bared by the retreat of Grand Pacific Glacier as to be practically unweathered. From a photograph by G. K. Gilbert, 1899. See page 20.

Lower Figure. — Chert Strata

The locality is on the northeast side of Halibut Cove, Kachemak Bay, Cook Inlet, close to the end of the outer gravel beach. From a photograph by G. K. Gilbert, 1899. See page 26.

DIKES IN MARBLE



CHERT STRATA

HELIOTYPE CO., BOSTON.

The larger dikes are of a coarse-grained diorite, varying to a hornblende-gabbro (74) in some of its phases, showing large hornblende crystals in a matrix of basic plagioclase and colorless augite. These larger dikes branch and send off fine-grained dikes of compact diorite (73) and quartz-diorite-porphyry (75).

All these dikes have narrow contact zones where they cut the limestones, which contain brownish garnet, pale green pyroxene and needles of tremolite in confused aggregates.

The same limestones make magnificent cliffs on the west side of the bay, near the Indian village in Queen Inlet; the white rock is everywhere most intricately cut by the dark diorite dikes.

On the western point of Reid Glacier the country rock is granite, a rock not before reported from this region. It is coarse-grained (61), with large pinkish orthoclase crystals and sugary quartz grains, the original hornblende being largely altered to chlorite. Plagioclase feldspar is very subordinate. There is some titanite and a small amount of zircon.

The granite is cut by a succession of dike rocks, the earliest of which appears to be a greenish aphanitic quartz-porphyry (59) of almost flinty appearance. Of later date are a succession of intrusions of rocks similar to those described from the eastern point; fine-grained compact diorites and diorite-porphyries in mostly narrow dikes; and last of all, an intrusion of quartz diorite, similar in appearance to the tonalite so abundant farther down the bay, which has invaded the whole series and often brecciated the black dikes so that the whole mass looks like a mosaic.

One of the most striking rocks collected in Glacier Bay is a very coarsely porphyritic diorite found only as a boulder on the shore in Hugh Miller Inlet, near the

glacier of that name. It consists of sharply idiomorphic crystals of brownish-green hornblende up to an inch and a half in length, embedded in grayish-white granular feldspar having the composition of an acid labradorite, all perfectly fresh. In the same specimen is seen granular diorite of the normal type, so that its porphyritic form is probably only a local phase of the tonalite. At the same spot was found an abundance of boulders of hornblende-schist, mica-schist and staurolite-schist similar to the specimens from the same vicinity described in Reid's report.

SKAGWAY AND WHITE PASS

Around Skagway and along the White Pass railroad to the summit are granitoid rocks, with basic segregations and later diabase dikes. The rock forming the bluffs east of the railroad station and pier is a coarse white granitoid tonalite (35) made porphyritic in aspect by the black biotite crystals. The feldspar is almost wholly a coarse plagioclase, twinned on two laws. It is an oligoclase albite with zonal extinction from $-3°$ to $+16°$ on M(010). The biotites are full of beautiful zircons. There is a small amount of green hornblende. The rock is cut here by a dike of aplite (34) a foot wide. Quartz phenocrysts, with biotite and muscovite, are visible in this aplite, and the whole ground has an exquisite minute granophyric structure in radiating feathers.

At Glacier Station and at White Pass summit is a coarse subporphyritic biotite-granite (42). The flesh-colored feldspar is an exceedingly fine-grained microcline microperthite; the white is a coarsely twinned plagioclase. At Glacier Station segregations of diorite in the granite are abundant from 4 inches to 2 feet in width, as well as white aplitic segregations. The diorite (40) is a fresh, black, hornblende-biotite rock, containing titanite visible with the lens. The hornblende has the strongest

pleochroism in brown and green. The plagioclase is zonal and is a complexly doubly-twinned labradorite.

A compact, fine-grained, dark, normal kersantite, with biotite as the only colored constituent, cuts the granite near Glacier Station. Another dike (38), of a normal diabase full of calcite spots, occurs at the same station, and a third dike of diabase (51), a foot wide, at the Summit Station.

YAKUTAT BAY

In Yakutat Bay most of the rocks seen in situ belong to the Vancouver or Yakutat Series, described in another chapter. Mr. Gilbert in crossing the moraine of the great Hubbard Glacier at the head of the bay, found among its boulders, besides the very abundant black slate and sandstone of the Yakutat series, a variety of crystalline rocks probably brought down by the glacier from the higher peaks of the St. Elias chain. As little is known of the nature of the rocks constituting this crystalline axis, it seems worth while to catalogue these rocks.

Glaucophane-quartz-schist (188). A bluish to greenish, compact rock with several parallel white quartz veins traversing the specimen. Under the microscope the fine granular quartz of which the rock chiefly consists is seen to be full of needles of strongly pleochroic glaucophane, which gives the rock its prevailing blue color, and of grains of epidote which are in places sufficiently abundant to color the rock greenish. A somewhat similar quartzite was found in boulders in the moraine of Hidden Glacier.

Amphibolite (190). A very massive, coarse, granular rock, consisting principally of green fibrous hornblende with small amounts of interstitial plagioclase and quartz. Possibly a basic segregation in a massive diorite.

Hornblende-gneiss (192). Blackish contorted gneiss, made up of dark needles of hornblende and plagioclase grains. Considerable rutile in twinned crystals, and a little quartz.

Epidote-quartz-schist (194). A mottled and banded greenish and white rock consisting chiefly of granular quartz with relatively large

magnetite grains, crystals of green mica, and abundant grains and prisms of epidote. A rock of uncertain origin.

Quartz-biotite-diorite (189). Snow-white feldspars with large sharp crystals of biotite.

Gneissoid biotite-granite (193). A fine-grained greyish granite with distinct banding brought about by parallelism of biotite plates.

Black micaceous quartzite (277).

With these crystalline rocks are probably to be grouped other boulders found on the shores of Yakutat Bay — coarse crystalline marble with black veins (292), coarse pegmatite with felted actinolite needles (291), poikilitic mica-diorite (279), and fine-grained epidote-chlorite-schist (278).

PRINCE WILLIAM SOUND

As in Yakutat Bay so also in Prince William Sound we found the rocks to consist mainly of the sandstones and shales of the Vancouver Series or of the closely similar Valdes Series of Schrader. Reference will be made to these later, in the section devoted to these rocks. At Landlocked Bay and at Virgin Bay the rocks seemed to have a different character. We went ashore at Landlocked Bay, the vertical walls of which shut us in like a well, and climbed several hundred feet over a wall of serpentine to the adit of a copper mine. The deposit of copper ore is a mass of quartz, with chalcopyrite, pyrrhotite, and small amounts of galena and sphalerite, occupying a shear zone in a rock of serpentinous character. Thin sections of this rock (186) showed a mass of fibrous serpentine in which are embedded shattered crystals of perfectly fresh labradorite and abundant augite, raveled out on the edges to colorless hornblende and serpentine. There are still traces of ophitic structure, and the rock is evidently a sheared and partly serpentinized diabase.

At Virgin Bay we found the rocks at the shore for a great thickness impregnated with pyrite and chalcopy-

rite, forming in some places solid compact ore, associated with a dark quartzite and with beds of fine-grained micaceous sandstone, greenish feldspathic sandstone and magnesian limestone. Just west of the mine the sandstone is cut by a thick diabase dike.

At the great nunatak of the Columbia Glacier, sandstones of the Vancouver Series are traversed by a rhyolite dike. It is narrow, disjointed and weathered, but was followed by Mr. Palache for more than half a mile. The rock, which weathers white, is blue-gray on fresh fracture, and shows distinct flow structure parallel to the walls of the dike. In thin section it is sparsely porphyritic, with embayed or completely rounded quartz crystals and occasional phenocrysts of orthoclase and oligoclase. The groundmass is either uniformly and extremely fine-grained (179) or beautifully spherulitic (178), the circular spherulites irregularly disposed, chiefly about the phenocrysts as centres of growth, the spaces between them being filled with fine granophyric intergrowths of quartz and orthoclase. This narrow dike of rhyolite and a single boulder of coarse yellowish granite found at the base of the nunatak, were the only rocks of igneous origin noted in the region about the Columbia Glacier.

We touched on the east side of Latouche Island, where there is also a deposit of copper ore on which work has been done. The ore consists of a large body of chalcopyrite and pyrrhotite mixed in places with much pyrite and at times with comby quartz. It is said to be an impregnation in the black slates of the region.

The rocks of this series, which have been called the Valdes Series by Mr. Schrader,[1] are much more metamorphosed than those of the Vancouver Series at Orca. They seem to occupy the area between Port Gravina and Port Valdes, and to extend far to the northeast on the

[1] 20th Ann. Rept. U. S. Geol. Survey, Pt. VII, p. 408. 1900.

mainland, and to the southwest through the double line of islands on the west side of Prince William Sound. It is probable that they are older than, and occupy the axis of an anticline in, the Vancouver Series.

COOK INLET

Mr. Palache landed at Halibut Cove, in Kachemak Bay, Cook Inlet, and found an interesting section of green and red radiolarian cherts, in thin and very regular beds separated by clay or shale partings, beautifully folded and contorted (plate II). With them are associated intrusive masses of diabase, much crushed and altered, showing in places a distinct spheroidal structure, the surfaces of the spheroids being largely covered with minute spherulites. Small amounts of sandstone and conglomerate are also present.

The series is cut by a group of conspicuous light-colored porphyry dikes, standing nearly vertical, parallel, and 20, 10, 50 and 60 feet in width, respectively. Under the microscope these dike rocks proved to be much altered dacite-porphyries, showing phenocrysts of embayed quartz, acid plagioclase much altered to calcite and kaolin, and occasional orthoclase in a granular to granophyric groundmass of quartz and feldspar. Chlorite is sparingly present throughout the rock, but the bisilicate from which it was derived could not be determined. The dikes are quite coarsely porphyritic near their centres, but toward the contact with the cherts become almost aphanitic. The cherts are whitened for a few inches from the contact but not otherwise altered.

With the exception of the dike rocks, this section bears an altogether extraordinary similarity in structure and lithologic character to the radiolarian cherts and associated igneous and clastic rocks of the Franciscan Series of the California Coast Range, especially well developed on the San Francisco Peninsula. These have been de-

scribed by Lawson,[1] who assigns them (doubtfully, owing to lack of fossils) to the Jurassic or to the very lowest Cretaceous.

Correlation over such wide distances, based only on lithologic similarity, has of course little value, but taken in conjunction with the other evidence for the existence of Mesozoic rocks in the Cook Inlet region, the facts may here be given a certain amount of significance.

From the steamer it appeared that the same chert series was present at Seldovia, lower down on the same side of the bay; but the rocks were not visited, and the only specimens brought aboard at that point were of shale and grey limestone impregnated with pyrite and pyrrhotite.

At Kadiak, on Kadiak Island, I received from Mr. W. J. Fisher, an old resident, several ammonites and specimens of *Inoceramus porrectus* Eichwald "from the mountains below Homer on Cook Inlet," and *Belemites paxillosus?* from Kamishak Bay on the western side of Cook Inlet. "The mountains below Homer" would indicate some point in the mountains back of Seldovia, which would be a new locality for these fossils, although other Neocomian fossils have been found near Port Graham.[2]

KADIAK ISLAND

The rocks around the village of Kadiak and on the adjacent islands are of the Vancouver Series. At Sturgeon Bay, at the west end of Kadiak Island, we found massive cliffs of igneous rocks. A dark uralitic diorite of granitoid structure (133), probably an altered gabbro, is cut by a lighter-colored grey granite (135), full of blue quartz,

[1] Geology of the San Francisco Peninsula. 15th Ann. Rep. U. S. Geol. Survey, p. 420. 1895.

[2] Dall, Coal and Lignite of Alaska, 17th Ann. Rept. U. S. Geol. Survey, Pt. 1, p. 866. 1896.

It is possible that these fossils came from the locality at Anchor Cape, Cook Inlet, mentioned by Dr. Dall on the same page.

which contains angular fragments of the darker rock. In many places both rocks are much epidotized, and veins of quartz-epidote rock (137) form large irregular masses in great abundance. Veins of coarse white aplite cut both of the above rocks, and this aplite proved to be of an exceptional variety, containing as its only bisilicate constituent a colorless pyroxene, and properly termed a pyroxene-aplite (136).

ALASKA PENINSULA AND SHUMAGIN ISLANDS

A zoological collecting party from the steamer, which spent some days at Kukak Bay on the mainland of the Alaska peninsula north of Kadiak Island, brought back an extensive collection of beautifully preserved fossil plants which are described elsewhere in this report. With the plant-bearing rocks, which appeared to be shales or fine ash beds, were brought coarse conglomerate and grits, containing limestone concretions, and said to overlie the plant beds. There were also coarse tuffs and specimens of altered augite-andesites, which were said to be very abundant at the locality. The relation of these rocks to the sedimentary beds was not determined. The series doubtless belongs to the Kenai Group of Dall, which is widely distributed along the peninsula.

We admired at a distance, and with exceptionally clear weather, the great volcanic mountains from Redoubt and Iliamna high up in Cook Inlet to Makushin on Unalaska Island, and had especially fine views of the wonderfully symmetrical Pavlof (frontispiece) and the grand Shishaldin. Steam seemed to be issuing from the spot high up on the main peak of Pavlof (the nearer peak in plate III), where the snow had apparently been removed by the heat. Great columns of steam could be clearly seen rising from the valleys low down the mountain and near the sea on the south and southeast slopes of the nearer peak.

EXPLANATION OF PLATE III

Mount Shishaldin

Mount Shishaldin is an active volcano nearly 9,000 feet high and of unusual symmetry, rivalling Fugiyama, the sacred mountain of Japan, in the beauty of its curves. It has never been visited by a geographer and is not known to have been ascended. Unimak, the island on which it stands, is a continuation of Alaska Peninsula, being separated only by a narrow strait. Like the rest of the Aleutian chain, it lies between Bering Sea and the Pacific Ocean.

Both views were taken by parties of the United States Fish Commission, the lower from Bering Sea in 1890, the upper from the Pacific in 1897.

MT. SHISHALDIN FROM THE SOUTH

PHOTOGRAPHS BY U.S. FISH COMMISSION JOHN ANDREW & SON

MT. SHISHALDIN FROM THE NORTH

Through the Shumagin and Sannak islands we had close view of many sea-cliff sections of recent volcanic rocks — some great columnar walls rivaling the Giants Causeway, and other cliffs showing many fine alternations of tuff beds and lava sheets.

ABOUT BERING SEA

UNALASKA ISLAND

At Dutch Harbor on Unalaska the low cliffs just northeast of the pier and company stores were studied. They are composed of an augite-andesite differing from any type found elsewhere on our journey, and apparently dating from an early part of the modern volcanic epoch.

The commonest variety (154) is a dark grey small-porphyritic compact rock. The distinct phenocrysts lie in a hyalopilitic ground with fluidal structure, the augites large, perfect and well twinned, the plagioclase (labradorite to basic labradorite) very fresh and full of lobate green glass, which sometimes almost replaces the feldspar and is then changed to a green radiate-fibrous mineral.

In another greenish portion of the bed (155) the feldspars are a half-inch square, are abundant, and are changed in varying degrees to calcite. An isotropic serpentine appears in perfect pseudomorphs after olivine.

The bed becomes reddish grey (156), and very porphyritic with abundant white feldspars. The latter show by their content of augite and calcite that they belong to the preceding type, but the groundmass is almost lacking.

The feldspar of all these types, while seeming very fresh, is full of inclusions and, as seen in polarized light, is broken up into confused patches by irregular twinning. The inclusions and twinning give them a peculiar habit which serves to unite the whole as a single mass, even when the rock (147) becomes slaty and like a phonolite,

and the few feldspars float in an exceedingly fine-grained ground, black-dusted and irresolvable.

BOGOSLOF ISLAND

The history of this volcanic island is given by Dr. Merriam in the first volume of the present series. It is the product of eruptions which began beneath the sea in 1795 or 1796 and continued at intervals for several decades. The sea is wearing it away. We visited the north side, crossing a broad beach to a steep cliff (fig. 5). A light grey andesite was found in the lower part of the cliff, and

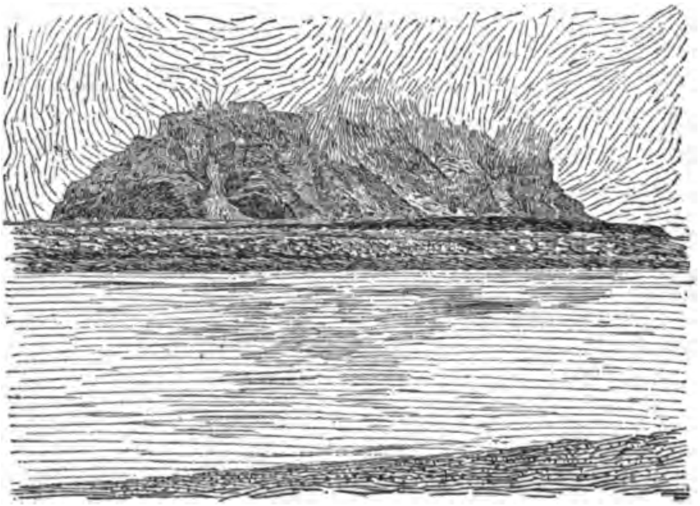


FIG. 5. BOGOSLOF VOLCANO, FROM THE EAST.
Photograph by E. S. Curtis, 1899.

above this a light-colored rusty tuff which seemed to be made up of fragments of the same andesite.

The andesite (plate IV, upper figure) is a pearl grey, rough-surfaced rock with dark brown hornblendes and green augites visible with the lens. The squarish plagioclase phenocrysts are beautifully zoned, made up of anorthite, with extinction 44° at centre and andesine, with extinction 16° on the outside. The deep red hornblendes

EXPLANATION OF PLATE IV

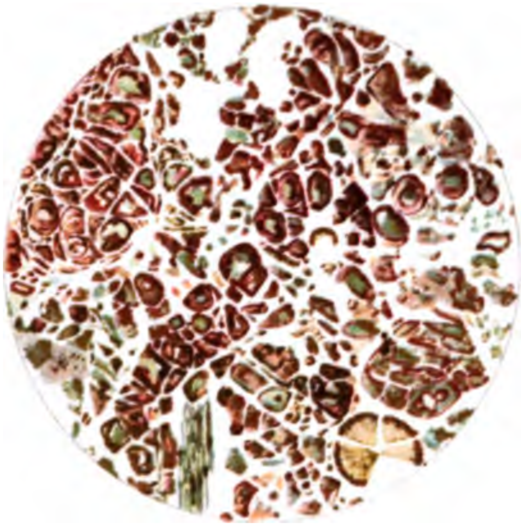
The figures are from drawings of thin rock sections as seen under the microscope.

Upper Figure.— Andesite

Compact lava from the east base of the Bogoslof Volcano, Bering Sea, collected in 1899. This volcano first appeared above the sea in May, 1796, being thrown up close to Ship Rock, a perishing remnant of an earlier volcano. It is sometimes called Old Bogoslof, to distinguish it from New Bogoslof, the eruption of which began in 1883. The history of the volcanoes is given in volume II, pages 291–335. The rock is described on page 30 of this volume. Drawn with natural light, but with nicols crossed to bring out the zonal structure of the plagioclase. Magnified 28 times.

Lower Figure.— Liparite

The specimen was collected as a rolled boulder from a beach on the north side of St. Lawrence Island, Bering Sea. See pages 38 and 41. Drawn with natural light. Magnified 28 times.



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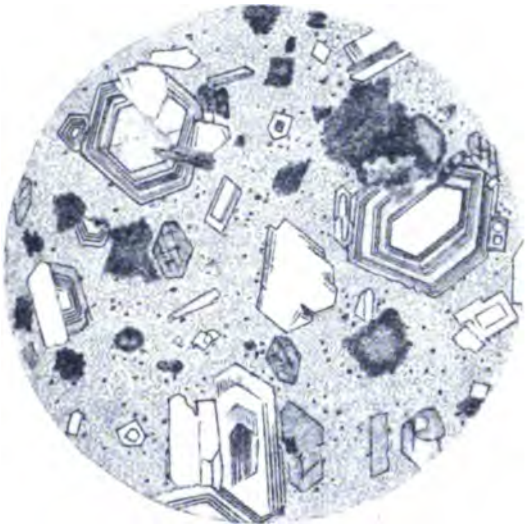

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1. LIPARITE, ST. LAWRENCE ISLAND
2. ANDESITE, BOGOSLOF ISLAND

are black-bordered. There is a glassy groundmass, full of feldspar microlites. The rock is closely like the lighter lava described by Dr. Geo. P. Merrill[1] from the bombs of the neighboring island Grewingk, or New Bogoslof, which protruded itself from the sea in 1883. It has a finer, uniform, dusty groundmass, and the hornblende and pyroxene crystals are smaller, equal in number, and more distantly scattered. The section of one feldspar crystal is cut parallel to the orthopinacoid (100), the long sides are formed by the traces of the domes (101) and the ends by those of (021), and a positive bisectrix appears almost central with the axial plane about parallel to one of the (021) faces. The extinction is $+41°$, showing that the central plate is an anorthite cut about at right angles to axis *a*. Rotated 60°, so that the axis *b* takes the place of *a* in the line of sight, the extinction is 52°. The first band outside the central plate extinguishes in a quite broad band from $+31°$ to $+33°$, or about at labradorite (ab_1 an_1). Within this band is a narrow thread which extinguishes at 41°, and is thus a nearly pure anorthite, like the centre; and directly inside this is a narrow band which extinguishes at $+22°$, and so is near ($ab_1 an_1$). The next broad band has three subordinate flutings, but the extinction progresses outwardly with much regularity from $+28°$ to 0°, or from labradorite (ab_1 an_1) to oligoclase (ab_4 an_1). The outer band is but slightly fluted, and extinguishes from $+20°$ to $-11°$, or from near labradorite (ab_1 an^1) to a nearly pure albite (a pure albite would demand an extinction of $-15°$ in this position).

PRIBILOF ISLANDS

At the Pribilof Islands we landed on St. Paul near the interesting Black Bluff, a symmetrical remnant of a cinder cone mostly dissected away by erosion of the waves. Mr.

[1] Proc. U. S. National Museum, vol. VIII, 31. 1885.

J. Stanley-Brown, to whose full geological description of the island[1] we were not able to add, kindly gave us several large blocks of the highly fossiliferous post-Pliocene rocks which are found in the coarse basaltic tuff of which the Black Bluff is made. These included fragments are rounded, and are charged with bivalve shells, mainly *Cardium*, which make up nearly half the mass. The rock is a firmly indurated marly clay, and yet since our specimens were brought away they have fallen asunder into a great number of pieces. The rock has been described by Dr. Dall,[2] who reports that all the shells are still found in the neighboring sea.

Several slides of the basalts of St. Paul were examined. One (157) is a glassy amygdaloidal basalt containing augite, olivine and plagioclase in well-defined porphyritic crystals in a black granulated glassy base. This is the 'newer scoriaceous lava' of Mr. Stanley-Brown.

The 'older' rock of Stanley-Brown (151) is a finely miarolitic, very olivinitic basalt of the Meissen type, with large red olivines, pink augite, plagioclase and magnetite, in a glassy base.

A third type of basalt was collected at the landing, from near the base of the Black Bluff cinder cone. It is intermediate in color between the others, more compact, but full of very large steam holes. The abundant olivine is in very fine, large, skeleton crystals, in a glassy base containing much magnetite and augite.

ST. MATTHEW ISLAND

A third of the way north across Bering Sea, from Unalaska, is the Pribilof group of which we have just spoken. A third farther north are St. Matthew and Hall islands.

[1] Geology of the Pribilof Islands, Bull. Geol. Soc. Am., vol. III, p. 496. 1892. See also Dr. Geo. M. Dawson, Geological Notes on Bering Sea, etc., Bull. Geol. Soc. Am., vol. V, p. 130. 1894.

[2] Bull. 84, U. S. Geol. Survey, p. 255. 1892.

Both seemed — as seen from the ship — to be wholly volcanic, but pebbles of crystalline rocks like those found on St. Lawrence Island, farther north, and on the Siberian mainland were found on the beach of St. Matthew, where they may possibly have been brought by the ice.

We made landing on the northeastern side of St. Matthew near the north end, and afterward coasted along the

FIG. 6. CLIFF-SECTION, NORTHEAST SIDE OF ST. MATTHEW ISLAND.

whole length of the island. We found it, as reported by Dr. Dawson, who touched at the southeast end and then coasted along the shore as we did, to be made up of bald, rounded hills, the residual portion of more extensive volcanic accumulations of some antiquity, but without modern cinder cones (figs. 6 and 7). We landed at the prominent point forming the southern border of the broad bay that

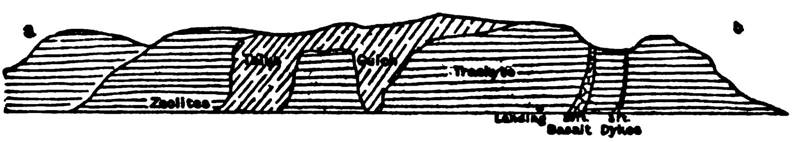


FIG. 7. CLIFF-SECTION, ST. MATTHEW ISLAND.
Enlargement of *a–b* in fig. 6.

sets into the middle of the island (fig. 8). Dr. Dawson describes the same section as seen from his ship.[1]

As we coasted along the eastern shore of the island there could be seen, extending for a long distance to the south of the bluffs where we landed, a lower bed of dark lava with a quite smooth upper surface. Above this lay a very thick bed of a light-colored lava which seemed to be the same as the light trachytic rock which made up the

[1] Geological Notes on Bering Sea, etc., Bull. Geol. Soc. Am., vol. v, p. 136. 1894.

bluff just mentioned. This was covered by a second heavy bed of a dark-colored lava, and the irregular line of boundary seemed to indicate that the lava had flowed over an irregular surface of the lower rock, and penetrated it extensively.

The high bluffs where we landed are made up exclusively of a fine-grained light trachyte rock in immense mass, cut by a few basalt dikes.

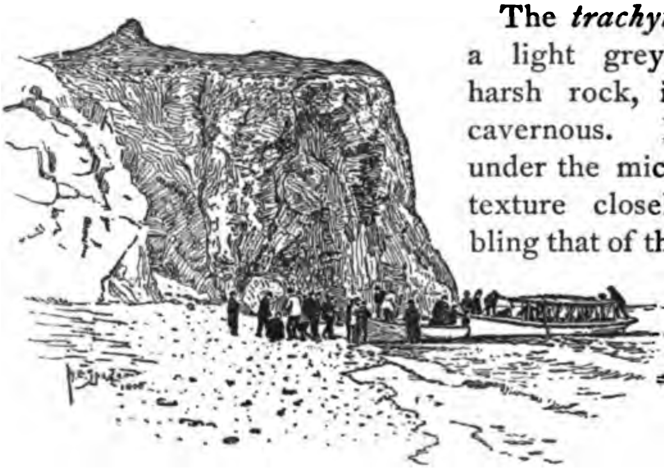


FIG. 8. CLIFF OF TRACHYTE, ST. MATTHEW ISLAND.

The *trachyte* (167) is a light greyish-white harsh rock, irregularly cavernous. It shows, under the microscope, a texture closely resembling that of the trachyte of Monselice, in the Euganean Hills, or of the finer part of the Drachenfels rock. The field is made up of small blades and shapeless plates of orthoclase, without distinct cleavage, polarizing with wavy shades from black to white, and with refractive index just below the balsam. There is considerable glass, and what seem to have been miarolitic cavities are filled with quartz. Scattered in this colorless ground are small blades and microlites of pale green hornblende, and traces of amber pyroxene in small shapeless grains, at times changing to hornblende.

A partial analysis of the rock was made by Mr. R. M. Chapin, assistant in the chemical laboratory of Amherst College.

SiO_2	57.62
Fe_2O_3, Al_2O_3, Mn_3O_4	24.47
CaO	8.74
MgO	1.34
K_2O	.30
Na_2O	1.00
Loss on ignition (H_2O)	8.58
	102.05[1]

The *basalt* of the dikes is a very fine-grained dull black rock, containing veins of chalcedony and calcite. It has an exceedingly fine ophitic structure, with much magnetite.

The other specimens were found as beach pebbles.

Aplite (*164*). A yellowish-white compact rock, much finer grained than the aplite from Plover Bay (described later) but much like one from St. Lawrence Island. It shows, over the whole slide, an exceedingly beautiful fine-grained micropegmatitic groundmass surrounding small feldspars with raveled-out ends. There are occasional larger phenocrysts of oligoclase, some quartz grains, and shreds of biotite.

Pyroxene-tonalite (*161*). A fresh and wholly granitoid rock of rather coarse, even grain, and with a pearl grey color dependent on the fact that the feldspars which make up most of the rock are blackish translucent in the central half and opaque flesh-colored on the outside. It contains much pyrite and little of any dark constituent. The feldspars are largely idiomorphic and strongly zoned. They are near albite-oligoclase, and are completely kaolinized inward to a sharp boundary. They are surrounded by a very complete micropegmatitic structure, which radiates out from them, growing coarser outward, and the lobes of the feldspar are seen as well in common light as with polarized because of the kaolinizing. The dark constituent is a pale pyroxene, nearly all changed to hornblende.

Augite-porphyrite (*163*). There is a brownish-red base with small brick-red porphyritic feldspars. The microscope shows it to be quite fresh, but with fissures and cleavage planes filled with red rust. The feldspars occur in very broad twinning bands, with extinction 38°–39° on the albite twinning plane, and so are very basic labradorite. The ground is hyalopilitic with a remnant of devitrified glass.

[1] Fe was weighed as Fe_2O_3 when some of it possibly was FeO. Mn was weighed as Mn_3O_4 when it undoubtedly existed as MnO. This brings the total above 100 per cent.

Uralite-porphyry (*162*). A fine-grained dark grey porphyry with whitish crystals 5–6 millimetres long. It has a fine-grained hyalopilitic base of feldspar needles, and the large augites are changed to uralite, except at center. There are many small phenocrysts of triclinic feldspar and magnetite.

Augite-andesite (*165*, *166*.) A nearly black rock, with small shining cross-sections of feldspar and augite. It shows a perfect hyalopilitic base of augite and plagioclase microlites, containing phenocrysts of very basic labradorite and augite, both very fresh, zonal, and full of inclusions of the base.

Glassy andesite (*176*). A dark red-brown rock, containing spots one-half inch square of aphanitic dark brown glass, thickly scattered in a dark grey small-porphyritic andesite. The rock also has inclusions of black basalt. The microscope shows a curious mixture of two glasses, one deep red, the other colorless. The red shows fine fluidal structure and runs out in threads into the other. The latter is full of labradorite phenocrysts, which are very broadly banded, zonal, full of glass inclusions, and much fractured.

HALL ISLAND

We landed at the middle of the east side of the island, beneath the letter *c* in the diagrammatic section given by Dr. Dawson.[1] His *b*, *c*, and the beginning of *d* are given in the figure below.

The view of the eastern wall as seen from the sea was very interesting (fig. 9). A great bed of a coarse dark

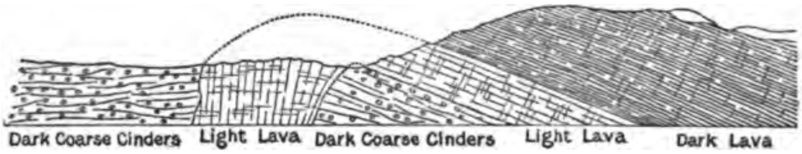


FIG. 9.—CLIFF SECTION, EAST SIDE OF HALL ISLAND.

tuff forms the bluff for a long distance, and is cut by what seems to be an immense dike or throat of light-colored lava — made up of great vertical columns. What appeared to be a great sheet flowing off from this core

[1] Bull. Geol. Soc. Am., vol. v, p. 137. 1894.

EXPLANATION OF PLATE V

Upper Figure.—Hall Island

The view is toward the north. The smooth upper slopes, carpeted by tundra vegetation, are contrasted with the shore cliff, which is barren because rapidly eaten back by the beating of waves against its base. The shore cliffs expose the anatomy of the island. From a photograph by E. S. Curtis, 1899. See page 36.

Lower Figure.—Plover Bay

The view is toward the south, or down the bay. It shows the southern half of the east shore of the bay. The more distant part of the shore is exposed to the waves of Bering Sea, as shown by its cliff. The coarse rock waste from this cliff has been built into a curved spit, on which the party landed. The collection of boulders from this spit illustrates the constitution of the mainland in the region of the cliffs. From a photograph by C. Hart Merriam. See page 42.

Hall Island, Bering Sea

Plover Bay, Siberia

to the right, rests on a dark cindery tuff below and is itself covered to the right by a thick bed of dark, apparently basaltic, lava. On nearer inspection, the great dike and the bed associated with it proved to be so full of inclusions as to resemble a coarse tuff, but the relations indicated by the dotted lines in the figure seem to be the true ones, and the great columnar mass seems to have been erupted through the tuff bed below, taking up many fragments from it and pouring out over the surface to form the bed to the right.

The lower bed is made up of large blocks of various dark rocks, basalts and andesites, with cavities filled with large masses of chalcedony, jasper, and amethyst.

One is a typical jet-black basalt of ideal freshness, the larger generation of plagioclase just visible. Another is a dark aphanitic rock with distinct square phenocrysts of plagioclase and few augites and olivines in a hyalopilitic groundmass. It may lie between basalt and andesite.

Other brown, brick, and red blocks are altered basalts so full of calcite and chalcedony that their original structure is disguised.

The *augite-andesite* (153) is porphyritic with abundant plagioclase (anorthite), rare augite, uralite and magnetite. The groundmass is fine hyalopilitic.

The *hornblende-andesite-porphyry* (158) has a dark green ground and is rather coarsely porphyritic. The groundmass is quite coarsely holocrystalline. The hornblende is in part basaltic and resorbed, in part uralitic as if from augite. Its cavities contain great geodes of fine amethysts and many thick veins of jasper and agate.

The rock which constitutes the upper bed (152) is light grey, having the aspect of a trachyte, but so full of minute fragments of various rocks that it is difficult to determine the original porphyritic constituents. The mass of the rock is a colorless glass full of fine brown dust, often

having streaks of yellowish glass which shows a partial fibrous devitrification. The glass penetrates some of the large plagioclase phenocrysts in a most elaborate lobate network, and these are certainly autogenous. Other feldspars are clear, zonal, and, like the normal feldspars of the andesites of the tuff bed, often fractured; they may be inclusions. Hornblendes, partly changed to calcite, and large shining biotites seem also to be original, and the rock may be called a *biotite-hornblende-andesite.* It is crowded with minute fragments of all the basalt and andesite types found in the lower bed through which it passed, and with many glassy types which were not identified from that bed.

Above the point where landing was made was the ruin of a hut. In following a dry brook bed up past this hut a ledge was reached, composed of a peculiar *hornblende-andesite* that seemed to belong to the black bed above the light middle bed. It is a dark fine-grained rock with distinct phenocrysts of feldspar. These are placed in a glassy groundmass, loaded with evenly distributed feldspar microlites forked at the ends, and long minute blades apparently of hornblende, which have been uniformly so far resorbed that they are crusted over with magnetite crystals and hardly determinable.

ST. LAWRENCE ISLAND

We landed on a coarse shingle beach on the north side of the island, about fifteen miles from the east end. The beach there is at the outer edge of a flat tundra plain, and is distant from the high part of the island, which we could see dimly through the fog. From this shingle we made a collection of rocks, and although none of them were seen in situ, it has seemed best to describe them because they presumptively represent the material of the neighboring cliffs, and because information as to the geology of the island is meager. Dr. Dawson figures grey biotite-

granite cliffs at Cape Chibukak, at the west end of the island, the granite being like that in Plover Bay.[1] He saw this overlain by horizontal brownish or reddish stratified materials, probably scoriaceous or agglomeratic. Capt. Hooper and Dr. Muir report having seen volcanic cones on the island.[2]

If Dr. Muir is right in the opinion that an ice-sheet covered the region, the boulders of this shingle may be erratics of remote origin; but according to the view of Dr. Dawson and Mr. Gilbert that there has been no general glaciation, the boulders are of local origin.

Following is a list of the rocks:

METAMORPHIC ROCKS

(*a*) *Dolomitic marble.* A white fine-grained statuary marble, slightly flamed with grey streaks, effervescing only slightly with strong acid.

(*b*) *Marble.* Clear grey fine-grained massive crystalline limestone.

(*c*) Black crystalline *limestone* full of small spots of white crystalline limestone, mostly angular, but many seeming to be sections of crinoid stems and small Chætetes-like corals (213). The section shows the presence of other, but indeterminate, fossils.

(*d*) Malacolite contact rock. *Kalk-silikat-hornfels* (209). The rock seems to be a common limestone banded regularly in white and black layers about one-eighth inch thick and slightly pyritous. Under the microscope it is seen to be made up of a uniform, rounded-granular mass of colorless pyroxene grains (with some biotite scales), which are finer in the dark layers (in which there are a few graphite grains) and coarser in the white layers and in veins branching from the latter.

A similar contact rock was found by Mr. Palache on contact of tonalite and the Paleozoic limestone in Glacier Bay. It makes fine blocks banded in flat black and white layers one-fourth inch thick.

(*e*) Reddish-brown fine-grained micaceous rock like the darker layers in *d*.

(*f*) Dark grey cherty *slate* with white spots that seem like traces of fossils (214).

[1] Bull. Geol. Soc. Am., vol. v, p. 138, 1894.
[2] Report of the Cruise of the Corwin, 1881, pp. 33, 140, 1884.

(*g*) Dark reddish-grey fine-grained massive pyritous *quartzite* (217). It contains much red secondary biotite, and tremolite grains. Among the clastic quartz grains are many plagioclase grains, which are angular or rounded and perfectly fresh so that the twinning bands run sharply up to the boundary. Their shape and association make them seem fragmental, like the quartz grains, and yet they appear too fresh to have survived the influences that have produced so much biotite and hornblende and they are probably the results of the same metamorphic agencies, which have here, as in many cases, produced rounded, pebble-like grains in a sandy matrix.

(*h*) Pure white, massive *vein quartz.*

(*i*) *Greywacke-hornblende-schist.* A metamorphosed greywacke, containing grains of granite minerals and slate; the broad interstices filled up with tufts of actinolite needles forming a cement of hornblende-schist for the whole.

This is a very remarkable rock. The granite quartz grains are full of cavities with reddish refringent CO_2 and moving bubbles. The feldspar and plagioclase grains are little changed, and yet the whole cementing mass is made up of minute delicately-tufted actinolite needles, which often radiate from the corners of the grains. The original cement may have been basaltic or have been the common calcareous and ferruginous cement of a sedimentary rock.

(*j*) A reddish-brown fine-grained micaceous *quartzite.*

(*k*) A dark grey cherty *slate*, with white spots that seem like remains of fossils.

(*l*) A black, almost aphanitic, *quartzite*, full of minute interlacing quartz veins.

(*m*) A black flinty pyritous *slate*, banded with thin white quartzite layers.

This is an interesting series of metamorphic rocks. The preservation of all the clastic grains of a greywacke intact while the paste has changed into an amphibolite is remarkable, and the preservation of grains of plagioclase in ideal freshness in a rock full of secondary biotite and hornblende is also noticeable.

The series seems to be due to contact metamorphism, and recalls many of the varieties of the crystalline rocks around Glacier Bay, where the limestones have been re-

ferred to the Carboniferous. It may have been derived from just such a series of rocks as the Vancouver Series, and it is associated with the same granitoid eruptives which accompany the Vancouver Series along the Alaska coast.

IGNEOUS ROCKS

(*n*) *Hornblende-biotite-tonalite* (372), identical with a boulder from Plover Bay described below.

Hornblende-biotite-tonalite (205), nearly identical with the above but showing many perfect amber-colored titanites just visible to the eye. This is represented in the collection by several varieties.

(*o*) Normal, rather coarse grained, *biotite-hornblende-granite* with abundant porphyritic Carlsbad twins of orthoclase.

(*p*) Dark grey medium-grained *granite*, with much more biotite than the other forms.

(*q*) *Aplite*. A very compact, almost aphanitic, pearl grey pebble; agrees almost exactly with the aplite from St. Matthew Island.

(*r*) *Porphyritic liparite perlite* (*218*). White feldspar crystals appear abundantly in a brick-red base of pitchstone.

The microscope (plate IV) shows a blood-red glass, affected everywhere by a perfect perlitic structure. The glass shades into deep red-brown spots or into pale red areas. The perlitic centers are often occupied by oil-green amorphous-appearing areas of microfelsite, which polarize fibrous and negative. This is also developed into minute spherulites, which are partly enclosed in the feldspar, and are broken and moved apart. The original fissures are now represented by broad bands which are colorless and granularly devitrified. The biotite is twisted and largely decomposed by fusion, with separation of black ore. The feldspars are often broken. The rock is an oligoclase-albite-bearing perlite. It represents the first step — the embryonic form — in the development of lithophysæ, in accord with the explanation of the process given by Professor Iddings. The separation of water at these points has caused the development of compounds having a green color, as is common in lithophysæ, and has caused disturbances there — the cracking of the spherulites, and polarization, while the glass around is unstrained and unaltered.

(*s*) *Augite-orthophyr* (*207*). A chocolate, felsitic base, with small flesh-colored feldspars and red biotite. The feldspars and the green augites are wholly decomposed under the microscope.

(*t*) Ideally fresh small-porphyritic reddish-grey *biotite-augite-andesite* 206), with the ground almost completely glassy.

(*u*) Dark grey fresh-looking gabbro-like *diabase*, coarsely ophitic, much calcified (208).

(*v*) Dark aphanitic *diabase* with ophitic structure but idiomorphic pyroxene (216).

(*w*) *Olivine basalt.* Hyalopilitic ground with distant squarish feldspars (275).

(*x*) (211) A fine-grained light grey *diabase.* The distant small phenocrysts lie in a hyalopilitic base. The augite is changed into a granular mass, mainly calcite.

PLOVER BAY

At Plover Bay (plate v and fig. 10) on the shore of Siberia the coast is mountainous, the bare cliffs rising sheer from the sea. On either side of the bay the cliffs seemed to be wholly made up of a light-colored granite. Coasting along the shore to the east, and after passing the first deep valley running up into the land, we saw rock of darker color, apparently a darker granite, and this continues for a long way east. The Eskimo village in Plover Bay was placed as usual upon a long low spit, and this is made up of coarse cobbles.

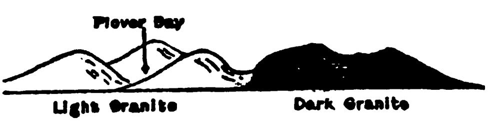


FIG. 10. SKETCH OF THE SIBERIAN COAST.

No soil or plant growth interrupts the view of the shore ledges. Only great streams of boulders occupy the steep gorges, and under the influence of the frost are slowly creeping downward. No sedimentary rocks or dikes were seen, to break the monotony of the bare granite.

The following rocks were found as boulders on the spit.

Hornblende-biotite-tonalite (174). A rather coarse, light grey, granitic rock, with small enclosures of fine grain and dark color. The plagioclase is subporphyritic, fresh, abundant, and markedly zonal; the orthoclase flesh-colored, in smaller and rarer anhedra; the biotite

in large scales changing to chlorite; the hornblendes in distinct porphyritic crystals.

Altered biotite-andesite (168). A pearl grey felsitic base, with opaque white porphyritic feldspars and distant black rods of biotite. With the microscope the whole is seen to be much altered, the plagioclase kaolinized, and the biotite changed to bright green chlorite. Many cavities are filled with secondary quartz.

Hornblende-andesite (206). This is a dark green compact rock with large brown porphyritic crystals of hornblende. It has a distinction of color as if it were brecciated. In one part the large porphyritic feldspars have many inclusions, the hornblendes have black resorption rims, and the biotite is changed to chlorite. In the other, all these minerals are brecciated but lie in a cryptocrystalline ground which is common to the two kinds.

Diabase (170). A clear grey harsh fine-grained rock with quite large cavities full of chlorite (delessite). It has the perfect ophitic structure, and the augite is much altered to chlorite. It contains inclusions of quartz with reaction rims of augite.

Olivine-diabase (171). A dark grey fine-grained harsh rock. The structure is almost ophitic, but the many short laths of feldspar and small crystals of augite are wholly idiomorphic and so approximated that an even thin seam of the black-dusted glassy ground intervenes.

Aplite (169). A fine-grained flesh-colored granitoid rock with miarolitic cavities containing orthoclase and complex quartz crystals. This occurs very abundantly in large blocks among the beach cobbles. The whole field is taken up by the most beautiful micropegmatitic structure, which surrounds and radiates from albite phenocrysts. The structure is well marked in ordinary light, since the whole is evenly kaolinized.

PORT CLARENCE

At Port Clarence, on the Alaska coast south of Bering Strait, we sailed past a magnificent flat-topped terrace, about 500 feet high, on the north, rounded Point Spencer, and cast anchor inside the long gravel spit of which this is the apex. We then went east across the bay in a launch, and landed at the mouth of a stream to take water. In fig. 11 the mouth of the stream is shown about two-fifths of the distance from the right of the picture.

The stream tributaries could be seen to come down from the hills in the background, which seemed from the ship to be quite modern volcanoes and to retain the crater form. We had not time to reach these hills over the tundra, but the large and half-worn fragments of an eruptive rock which we found in the bed of the stream seemed certainly to come from them.

The rock is an amphibolite derived from an eruptive pyroxenite (177). It is of a dull pale greenish color, is full of rust-stained fissures, and though evidently altered shows remains of broad augite cleavage surfaces. Under the microscope appear cores of pale amber augite mostly changed to a fine felted mass of actinolite needles. There are many grains of titaniferous magnetite bordered by broad bands of fine opaque white leucoxene. The broad patches of augite show no trace of intervening feldspar.

FIG. 11. COAST OF PORT CLARENCE, ALASKA.

Another slide shows that some of the same material has been further changed into isotropic serpentinous matter full of rhombs of dolomite.

The rocks exposed in the cliff along the shore are slates of the Vancouver Series, to be described below.

THE VANCOUVER SERIES

A series of dark slates, sandstones, greywackes, tuffs, and subordinate calcareous beds, often strongly cleaved, or jointed all to pieces, and filled with quartz veins, but otherwise not greatly advanced in metamorphism, is widely distributed in Alaska. It extends from Vancouver Island on the south, past Sitka and Glacier Bay to

Yakutat Bay, Prince William Sound, Kadiak, and Port Clarence in the far north near Bering Strait. The observations given above (page 41) show its possible presence on St. Lawrence Island. It is even more probable, from the observations of Dr. Dawson,[1] that the same series is present on Atka Island and Attu Island, the westernmost of the Aleutians, where the rocks comprise (1) much altered and indurated volcanic materials with purplish, greenish and grey colors, partly eruptive, partly clastic, (2) fine-grained feldspathic clastics which pass into a black compact material, apparently a true argillite. They are strongly folded and eroded.

The series was described first by E. Hoffman in 1829 from Sitka, in his Geognostische Beobachtungen, as a fine-grained siliceous greywacke with interbedded clay slate.[2]

Dr. Dawson, in his report cited below, says that the name Vancouver Series was first applied by Dr. Selwyn in 1871 to the similar argillites, quartzites and limestones, with interbedded volcanic materials, of the southern part of Vancouver Island.[3]

In 1886 Dr. Dawson applied the name Vancouver Series to the entirely similar beds in the northern parts of Vancouver Island and in the Queen Charlotte Islands to the north,[4] in which fossils characteristic of the Alpine Trias have been found; namely, *Monotis subcircularis* Gabb, *Halobia* (*Daonella*) *lomelli* Wissman, *Aulacoceras charlottense* Whiteaves, *Arcestes gabbi* Meek,

[1] Geological notes on some of the Coasts and Islands of Bering Sea and vicinity. Bull. Geol. Soc. Am., vol. v, p. 122. 1894.

[2] Becker, Gold Fields of Alaska, 18th Ann. Rep. U. S. Geol. Survey, pt. III, p. 43. 1898.

[3] This would seem to be a lapse of memory, as in the report of Dr. Selwyn the term Cascade Mountains and Vancouver Island Series is applied to a wholly crystalline complex of gneisses, diorite-porphyries and limestones, placed below rocks containing Paleozoic fossils. Geol. Survey Canada, Rep. Prog. '71–'72, p. 64. 1872.

[4] Rep. on northern part of Vancouver Island, Geol. Survey of Canada, Ann. Rep., N. S., vol. II, pp. 9B–10B. 1886.

Celtites vancouverensis Whiteaves.[1] In 1889 he extended the name to the argillites of Wrangell, together with those met with near Juneau, at Sitka, and along the east side of Lynn Canal, including also the altered volcanic rocks found in association with them, though no fossils were obtained at these northern localities.[2]

The same rocks were called the Yakutat System by Professor I. C. Russell,[3] who gave them a much higher place in the series than we have. They were observed by him under great difficulties during the ascent of Mount St. Elias.

Similar rocks in Prince William Sound have been called the Orca Series by Mr. F. C. Schrader.[4] He parallelizes them provisionally with the Kenai Series of Spurr in the Yukon District (1896), the Yentna Series of Spurr in southwestern Alaska, and the Kenai Series of Eldridge in the Sushitna River (1898), and assigns them to the Eocene or Oligocene.[5]

Mr. E. O. Ulrich, who has studied the fossils gathered from Kadiak and Yakutat Bay, finds that their age is, with little doubt, lower Jurassic. (See his paper in this volume.)

Most of the Jurassic fossils described from the northwest are in limestone and are assigned to much higher levels in this system. A few distinctly Alpine Triassic forms have been described from shales assigned to the Vancouver Series by Dr. Dawson, as noted above. It is also noted that the shale at Cold Bay, containing *Monotis*,

[1] Rep. on northern part of Vancouver Island, Geol. Survey of Canada, Ann. Rep., N. S., vol. II, p. 108B. 1886.

[2] Rep. on Yukon District, Geol. Surv. of Canada, Ann. Rep., N. S., vol. III, p. 32B. 1889.

[3] Expedition to Mt. St. Elias, National Geographic Magazine, vol. III, p. 167. 1891.

[4] A Reconnaissance of a part of Prince William Sound and the Copper River District. 20th Ann. Rep. U. S. Geol. Survey, pt. VII, p. 404. 1900.

[5] 20th Ann. Rep. U. S. Geol. Survey, pt. VII, p. 413. 1900.

is lithologically like the Kadiak slates containing the fossils here under discussion. It will be difficult for a long time to separate these nearly barren beds, which are connected by many lithological similarities, into a Triassic and a Jurassic series, and I have therefore left the name 'Vancouver Series' to cover them all, with the limits of usage given it by Dr. Dawson.

SITKA

The prevailing rock about the town of Sitka is a black slate, often greatly crumpled and jointed.

A very interesting and characteristic rock of this series is the tuffaceous greywacke found in typical development at the mouth of Indian River, near Sitka, and elsewhere at many places on the island. It has the aspect of a firm dark massive coarse sandstone, in which many of the grains consist of fragments of other rocks.

A slide cut from the rock at the mouth of Indian River (203) proves it to be fine-grained indurated tuff, containing many clastic quartz grains, together with shattered fragments of black carbonaceous shale, of a hyalopilitic andesite groundmass, and of a darker ophitic eruptive, probably basalt. It may be thought of as the product of explosive eruptions, which shattered and mingled several kinds of volcanic rocks with the sands and fragments of the muddy beds, the clastic ingredients being indurated by the heat of the eruptions in which they were involved, like the modern shell marls enclosed in the tuffs of the Pribilofs, already described.

The beds at the mouth of Indian River were examined with care. The massive tuffs contain many small angular fragments of the black slate, which grow larger toward an adjacent area occupied by shattered slates in which the fissures are filled by small injected mud veins of the tuff which accompanied the eruptions. The dip and strike

of the slates in this region appeared to be quite constant, indicating only a moderate degree of shattering of beds that are essentially in place.

It will be seen that neither for this place nor for Silver Bay are we able to accept the ingenious theory of a pyroclastic diorite advanced by Dr. Geo. F. Becker.[1]

At the hot springs on Baranof Island near Sitka the country rock is a highly metamorphic sandstone, often schistose, and even gneissoid in appearance. It is intimately penetrated by dikes and massive intrusions of granite, which has caused, at least in part, the greater metamorphism. These dikes often run along the strike of the sandstone, causing much contortion of the beds, and many fragments of schistose sandstone are included in the granite.

Mr. Devereux and Mr. Palache visited the Chicago mine, on Baranof Island, one and one-half miles from the head of Silver Bay, and at 1,400 feet elevation. The approach was over the same grits, greywackes, sandstones, and thin shaly bands. The mine is a development tunnel only. The quartz body is said to be continuous for three or four miles, and consists of a banded bluish quartz or chalcedony with lenses of pale pink rhodonite. The outcrop is black with manganese stains. The walls are slate and greenstone. The mineral content of the quartz seems small, chiefly scales of pyrite and pyrrhotite. Mispickel is found in the slate near by. Quartz veins, bunches and stringers occur quite abundantly in the slate.

Mr. Gilbert climbed to the summit of Mount Verstovia, 2,800 feet high, directly back of Sitka, and found the same conglomerate and sandstone all the way to the top.

[1] Gold Fields of Alaska, 18th Ann. Rep. U. S. Geol. Survey, Pt. III, p. 43. 1898.

YAKUTAT BAY

At the camp made beside the Malaspina Glacier, on the west side of Yakutat Bay, Mr. Palache was able to see the sandstone and grits at one place only, near the base of the mountains. They here offered no peculiar features.

On Osier Island, at the mouth of Russell Fiord, and on the mainland south of the island Mr. Gilbert found soft black shale and a light grey, fine-grained, feldspathic and slightly micaceous sandstone. Farther up the fiord, on the shore of Nunatak Inlet, near the Nunatak Glacier, he found a considerable tract covered by a rather crystalline fissile blue slate, much more metamorphosed than most of the rocks of this series in this region.

Still higher up in Russell Fiord, landing was made near a small glacier opposite the mouth of the valley occupied by the Hidden Glacier. Here the Yakutat Series consists of black shales including layers of fine dark sandstone, with veins and large pockets of quartz containing copper stains. These rocks have been invaded by a granitoid intrusive rock, fine-grained and gneissic at the contact, coarser and granular at a little distance, which is similar in character to the biotite-tonalite found so abundantly farther to the south. It has altered the sandstone at the contact to a micaceous quartz-schist. The presence of this intrusive here confirms the correlation of the Yakutat Series with the Vancouver Series as found at Glacier Bay, on Baranof Island and at Beaver Cove on Vancouver Island, far to the southward.

Five miles south of Hidden Glacier in Russell Fiord a section made in the Yakutat Series shows black shale, much shattered, and kneaded with coarse sandstone; buff sandstone full of narrow calcite veins; grey limestone with white bands containing on the borders greenish serpentine inclusions; and heavy beds of coarse conglomerate

containing pebbles of shale, sandstone, white marble, granite, vein quartz, and a green porphyrite. The strike of these beds is N. 10° E.,[1] dip 45° to 80° W.

Several vertical beds of white limestone appear in the distance like waterfalls coming down the steep face of the high cliffs along the north side of Russell Fiord. One of these, just west of the Indian camp near Point Latouche, was examined, and found to be very coarse white crystalline limestone, reaching thirty feet in width, occupying a fault fissure in the black slate.

The characteristics and distribution of the Vancouver or Yakutat Series are very fully given by Professor Russell.[2] All the region around Yakutat Bay and its dependencies, except the northern slope of Mount Cook, seems to be underlain by rocks of this age, partly covered by the newer Pinnacle system.

PRINCE WILLIAM SOUND

In Prince William Sound the same sandstones and slates to a large extent form the country rock. Hinchinbrook (or Nuchek) and Hawkins islands appeared to be made up of them, showing beautifully stratified and contorted exposures. At the bay on the north side of Hawkins Island the sandstone beds are numerous and the dip is high. Where we stopped at Orca they stand on edge, and are composed of black slate with much dark quartzite. The slate contains obscure fossils.

The sandstone weathers to a peculiar greenish color, giving the surface appearance of serpentine. Many veins and veinlets of quartz cut the formation in all directions. At the Columbia Glacier, studied by Gilbert and Palache, the rocks are the same and the moraines are wholly filled

[1] All bearings are corrected for magnetic declination.

[2] Expedition to Mt. St. Elias, National Geographic Magazine, vol. III, p. 167. 1891.

with this material. At the conspicuous nunatak they are cut by a rhyolite dike, already described on page 25. The same slaty rocks seem to compose the shore to the westward, including College and Harriman fiords. We landed at the Bryn Mawr Glacier, in College Fiord, and found the slates cut by two small aplite dikes.

This series of rocks has been called the Orca Series by Mr. F. C. Schrader.[1]

KADIAK ISLAND

The eastern half of Kadiak Island and the adjacent archipelago are made up of the Vancouver slates without intrusives. Only one block of a scoriaceous basalt was found on the shore at Kadiak village, and that may have been brought there as ballast. Figure 12 shows the village and a group of smaller islands off the coast. The shore was examined for several miles on either side of the town, and the mountain from the slope of which the picture was taken was ascended. Everywhere the slates were found, and the fossils were especially abundant along the shore concealed by the hill in the foreground, and in the bluff coast of Pogibshi Island opposite the town. The tip of this island, where several unique specimens were obtained, is represented in figure 13. A photograph (plate VI) showing the cleavage was taken by Mr. Gilbert on the slender cape running to the right from the same island. At the cleared place in the middle of the most distant island but one (Woody Island) is the station of the North American Commerical Company. Just to the left of this is a locality at which Dr. Dall, in 1895, found bivalve shells in association with the more common fossils of the slates.

The section of slate in plate VI shows both bedding and cleavage. The bedding dips there 60° to the SE, the

[1] 20th Ann. Rep. U. S. Geol. Survey, Pt. VII, p. 404. 1900.

FIG. 12. GROUP OF ISLANDS NEAR KADIAK.
The nearest large island is Pogibshi. Beyond it are Woody and Long islands.

strike being NE. The principal cleavage strikes somewhat east of north, and has a variable inclination, dipping 60° to the west in the harder, more arenaceous beds, and being nearly vertical in the more argillaceous.

Southwest of the wharf at Kadiak village the black slates strike N 5° E and dip 80° W to vertical. Twenty rods beyond the houses *Terebellina* is abundant. Farther southeast the slates alternate with beds of sandstone a foot thick, and strike N 50° E, dipping 30° W. The cleavage is N 55° W, dipping 45° SW. Beyond are grey fine-grained sandstones, with included slate pebbles, and oval depressions one-fourth inch long from which concretions have been dissolved. The strike is N 15° W, changing to N 25° W; dip 70° W, changing to 90°.

Dr. Dall says:[1] "the

[1] Report on Coal and Lignite of Alaska; 17th Ann. Rep. U. S. Geol. Survey, Pt. 1, p. 872. 1896.

EXPLANATION OF PLATE VI

Cleavage in Slate

The slate is of the Yakutat Series. The locality is on a slender cape of Pogibshi Island, about a mile southwest of Kadiak village. The view is toward the northeast, in the direction of the strike. The dip is northwest, at about 60 degrees. Not far away the planes of bedding show fossils. See page 51.

The beds are argillaceous, with varying admixtures of sand. In the purer argillite layers the cleavage is nearly vertical; in the more arenaceous layers it departs widely from the vertical. The dip of cleavage planes is here to the southeast, or opposite to the dip of bedding planes. In the opposed limb of a local fold the bedding dips southeast and the cleavage dips northwest. From a photograph by G. K. Gilbert.

CLEAVAGE IN SLATE

HELIOTYPE CO., BOSTON.

fossils found [on Woody Island] were very few; one apparently a *Posidonomya*, the only bivalve; a singular organism like a flattened *Dentalium*, but which is probably a worm tube; and an alga which Professor Knowlton identifies with Eichwald's *Chondrites heeri*, were the most conspicuous. It is not improbable that these slates are of Triassic age, but a final determination will require more prolonged study."

FIG. 13. FOSSIL LOCALITY, POGIBSHI ISLAND.

Professor Alpheus Hyatt reports upon these fossils:[1] "The slab from Woody Island, Kadiak, has what appears to be a large, much compressed species of Posidonomya, and I should think it might be Triassic or older, but there is no solid basis for this opinion."

The fossils from the newer Mesozoic of the Alaska and Kenai peninsulas are from rocks of very different character from the Yakutat Series. A large slab with *Monotis salinaria* from Cold Bay, west of Kadiak, across Shelikof Strait, is lithologically very like the Vancouver slates.

In the same way the limited occurrences of Paleozoic fossils in Alaska are in limestones and rocks very unlike those here under discussion.[2]

PORT CLARENCE

The slates which make up the shore about Port Clarence dip about 45° westwardly and have intercalated beds

[1] 17th Ann. Rep. U. S. Geol. Survey, pt. 1, p. 907. 1896.

[2] Dr. Dall, Coal and Lignite of Alaska, 17th Ann. Rep. U. S. Geol. Survey, pt. 1, pp. 864–5. 1896.

of brown sandstone much cut by small veins. They contain a few of the fossils found elsewhere in the series.

The main rock is a dark grey, very thinly fissile argillite, not greatly removed from a shale, and often containing fossils. It is satiny, from a delicate corrugation in the laminæ on which the fossils lie, and perfectly jointed. This jointing is in places approximated, and passes into a perfect slaty cleavage, on the surfaces of which is developed a minute crumpling (like the primary one mentioned above), across which the color banding runs. Some of the shales are calcareous and run into thin beds of limestone. They are much cut by quartz veins, which are often comby and reach several inches in thickness. A careful assay made by my son, E. H. Emerson, found only a trace of gold.

In several cases a curious structure has been formed in the fissures. Small cubes and radiating balls (probably once of pyrite but now of iron rust) have developed in the fissures and on the face of the slate, and around them has gathered a rim of white, finely fibrous quartz. This is in one case in continuity with an ordinary quartz vein. The fibres extend straight out from the pyrite in two opposite directions, or in a curve which soon becomes radiate.

SUMMARY

It was only at the deserted village at Cape Fox, east of Duke Island, that we saw old-looking gneisses comparable with the pre-Cambrian or the most highly altered Paleozoic rocks in New England. The rocks at New Metlakatla may be of the same age.

Next comes, at two widely separated localities — the Muir Glacier, near Sitka, and St. Lawrence Island, off the coast of Siberia — a series of coarse crystalline limestones, with greywacke and cherty quartzites, which have been

determined by a few fossils to be Carboniferous. In both regions these sedimentary rocks occupy but small areas as compared with the eruptive rocks which have cut and altered them, and it is interesting that the post-Carboniferous igneous rocks are of the same type at these widely separated localities. We may call them a tonalitic series, from the most prevalent variety.

From the most southern point touched on Vancouver Island to Plover Bay in Siberia we found large areas of granitic rocks. Granite proper is abundant, especially along the whole length of the White Pass Railroad and around Sitka and the Reid Glacier. A far more abundant and characteristic rock is a biotite-tonalite of light color, coarse, even, granitoid texture, and very rich in titanite. This continues through Fraser Reach, Graham Reach, Grenville Channel, and Chatham Sound, and around the Muir Glacier. Various porphyries and basic rocks — diorite-gabbro and diabase — are associated with the tonalite, but in a very subordinate way.

These rocks are wanting along the coast north of Skagway up to Port Clarence, but reappear in great force on the Asiatic coast around Plover Bay, and are apparently in place on St. Lawrence Island.

The Vancouver Series, which extends along the whole coast from Vancouver to Bering Strait, seems to be of Triassic or early Jurassic age. It is a formation of shale, with subordinate sandstone and almost no limestone. There are very few igneous rocks connected with the Vancouver Series. These are all basic and have a tendency to change into serpentine. The pyroxenite at Farragut Bay, near Fort Wrangell, the serpentinized diabase at Landlocked Bay, and the diabase dike at Gladhaugh Bay, in Prince William Sound, are examples, as also perhaps the serpentinized pyroxenite from the cones seen across the tundra at Port Clarence, north of Cape Nome.

The curious tuff at Indian River, near Sitka, shows only andesite and basalt.

The very interesting radiolarian chert of Halibut Cove, on Cook Inlet, which we compare with the Franciscan Series of California, of Jurassic or early Cretaceous age, has its own peculiar igneous rocks, crushed and altered spheroidal diabases and dacite-porphyries.

At Dutch Harbor we studied the older beds of the newest series of volcanic rocks — highly altered augite-andesites — and through the Shumagin and Sannak islands and in the sea cliff sections on Hall and St. Matthew islands we were able to examine the whole series of these andesitic, trachytic, and basaltic rocks. We saw the newest of the series in the basaltic tuff cone at Black Bluff, on St. George Island, and in the wall of pearl-grey andesite on Bogoslof.

ALASKA-TREADWELL MINE

THE ALASKA-TREADWELL MINE

NOTES ON THE GEOLOGY OF THE MINE AND VICINITY

BY CHARLES PALACHE

Several days were spent in studying the Treadwell mine and its vicinity and the canyon of Gold Creek back of Juneau. Thanks to the courtesy of the superintendent of the mine, Mr. Corbus, every opportunity was given me to see the mine workings, both above and under ground, and I take pleasure in expressing to him here my thanks for his many services.

The Treadwell mine was very fully described by Mr. Becker,[1] who discussed the nature of the somewhat unusual rocks in which it is located, and the probable sequence of geologic processes leading to its formation. My opportunities for the study of the mine did not suffice for more than a hasty survey of the ground, and anything that I may be able to add to Mr. Becker's description is concerning the newly opened parts of the mine, which was very rapidly developed between the time of his visit, 1895, and my visit in 1899.

[1] 18th Ann. Rep. U. S. Geol. Survey, Pt. III, p. 64. 1898.

At the time of my visit active mining work was chiefly confined to the 110-foot level, much stoping being done there, and all ore taken from the open pit above being run down to that level in chutes and hoisted from there through the main shaft.

The 220-foot level was also well opened out by drifts

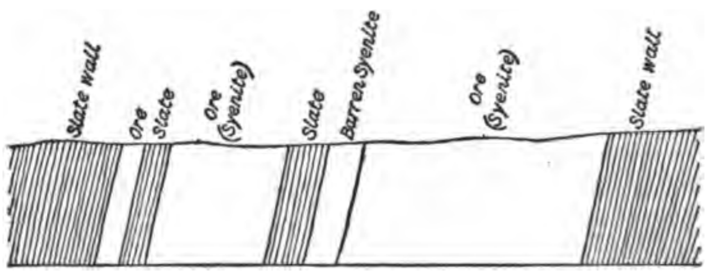


FIG. 14. DIAGRAMMATIC SECTION OF TREADWELL MINE; OPEN PIT.
Scale, 1 inch = 150 feet.

and cross-cuts, and stoping had already been begun on a limited scale. Below this, levels cross-cutting the deposit had been run out at 330 and at 440 feet, and were open to inspection, but no drifting had yet been done from them. About 2,000 tons of ore a day were being lifted from this mine through the two shafts.

Two sections across the deposit were roughly measured,

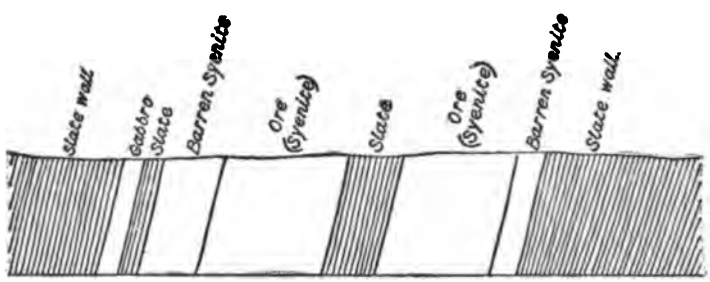


FIG. 15. DIAGRAMMATIC SECTION OF TREADWELL MINE; 440-FOOT LEVEL.
Scale, 1 inch = 150 feet.

one at the open pit level, the other in the cross-cut on the 440-foot level (reproduced in figs. 14, 15). From these sections it may be seen that the width of the deposit be-

tween walls diminishes from about 400 feet at the pit level to about 350 feet at the 440-foot level, and the thickness of ore in the lower level is still further reduced by the presence of two bands of barren syenite, one 50, the other 20 feet in width, and by a slate 'horse' about 45 feet wide. In other words, the ore body which at the pit level had a thickness of about 300 feet has diminished by one-third at the 440-foot level. It was expected by the superintendent that drifting along the deposit would show this to be only a local pinching of the ore-body, but whether this expectation has been confirmed I am not informed.

The portion of the Treadwell deposit lying next south of the Treadwell mine and known as the '700' claim was being exploited by an open cut in 1899, and ore was being taken out to a width of about 100 feet.

No work was being done on the Alaska-Mexican mine, the next claim south, the mill being run on ore from the other mines.

At the southernmost of the developed claims, the Ready Bullion, vigorous operations were being conducted, and had shown that here the regular Treadwell lode was much reduced in width, varying from thirty to not much over sixty feet; but in the foot-wall of the lode a well-defined quartz vein forty feet in width, dipping at a lower angle to the west and carrying much higher values, was discovered. Its relation to the main lode had not been thoroughly developed by deep exploitation; but it seemed to consist almost entirely of vein quartz, and thus to differ essentially in origin from the larger replacement deposits.

Collections of ore and wall rock were made from all the parts of the mine visited, and their study confirms the results of Mr. Becker in all respects. The ore consists of a somewhat silicified sodium-syenite, which has been intruded as a large dike in the prevailing black slates of

the region, and later charged with gold-bearing pyrite by mineralizing solutions.

The *sodium-syenite* consists essentially of almost pure albite, in granular or partly idiomorphic aggregates, with which is more or less orthoclase and quartz, the latter generally in micropegmatitic intergrowths filling the interspaces of the albite. Ferromagnesian constituents were probably present in the unaltered rock, but their nature can not now be determined, beyond the fact that there was a small amount of biotite, now changed wholly to a greenish mica or to chlorite. Other original accessory constituents are apatite and titanite, fairly abundant, and sparing zircon. The secondary products are, first and most important, pyrite, which is abundant in all slides in sharp crystals, often surrounding small feldspar crystals and often associated with calcite. Calcite and sericite are very abundant, being developed especially in the centers of albite crystals, which they sometimes completely honeycomb, leaving only a narrow rim of unaltered feldspar. Grains of epidote and zoisite are sometimes abundant in the feldspar, and rutile in sagenitic groups is seen in the chloritized biotite. Quartz in evidently secondary forms is surprisingly small in amount, although this is accounted for partly by the choice of material for slicing, which was the freshest obtainable. It should, however, be said that sections from rocks which were pronounced by those most familiar with the ores to be undoubtedly gold-bearing, and sections made from portions of the syenite shown by assay to be barren, were practically identical in character, there being but little observable difference in decomposition or in content of quartz or pyrite. Hand specimens of the barren rock usually showed a darker color, due to the greater amount of chlorite, but this distinction was not constant. In fact it was continually a matter of surprise that the syenite was so

little altered where it was known to be gold-bearing, for all descriptions of the ore had led me to expect difficulty in recognizing the original character of the rock, whereas in nearly all my specimens the syenitic nature of the rock is clearly visible, and the microscope only confirms the judgment of the unaided eye as to its comparative freshness.

The foot-wall of the deposit is uniformly formed by the black slate. The hanging-wall also is largely constituted by the same rock, but in places the slate is separated from the ore by the dark green, highly altered, igneous rock called gabbro by Becker. This rock was seen in the hanging wall of the Treadwell mine at the 220 and the 440 levels, at numerous points along the vein between the Treadwell and the Mexican, and in the open pit of the Mexican mine. It has the appearance, now of an amphibolite, now of serpentine, now of a hornblendic diorite or gabbro. It was not studied in thin section. It contains fragments of the albite-diorite, and is undoubtedly younger than this, as stated by Becker.

The mineral content of the Treadwell deposit is not much varied. Quartz is the chief gangue, if the original rock constituents are left out of account; but at times calcite, or an iron-bearing carbonate, largely takes the place of the quartz as a vein filling. In the open pit of the Mexican mine specimens of ore were found in which narrow veins of delicate pink rhodochrosite or manganese carbonate traversed the syenite and accompanied the pyrite. This mineral seems not to have been observed there before. Of metallic minerals pyrite is far the most important. Mr. Corbus gave me a specimen of ore showing considerable free gold along with pyrite and films of graphite, but such occurrences are very rare. He said that graphite was sometimes sufficiently abundant to be a source of annoyance, by fouling and greasing the plates

in the mill, but it is not conspicuous in the ore. Chalcopyrite was found in small amounts in both Treadwell and Mexican ores, but no other sulphide was seen except pyrite. Small veins of short-fibred asbestos are sometimes formed on shear planes in the altered gabbro.

As regards the tenor of the deposit in gold, I was informed that there was no apparent change with depth to the lowest parts reached (the 440 level) although, as stated above, there was here a considerable body of syenite that, while containing pyrite in abundance, was practically barren of gold. The slate was everywhere found to be barren. The serpentine forming the hanging-wall on the 440 level was said to show low values, not to exceed fifty cents a ton.

At the time of our visit the Treadwell Company had five mills running continuously with 880 stamps, and were crushing approximately four tons of ore per day per stamp. It was interesting to note the encroachments made in the shallow water of that side of Gastineau Channel by the vast amount of tailings thus being continuously poured into the bay.

The town of Juneau stands on the mainland just across the channel from the Treadwell Mine. The black slate which is so conspicuous on Douglas Island about the mine is not found in Juneau, its place being taken by a series of much more highly crystalline schists.

In the town of Juneau on top of a little hill above the wharf were found outcrops of a bluish *hornblende schist* (Nos. 24 and 26). This rock is highly schistose but of rather coarse texture, showing to the unaided eye only fibrous bluish hornblende. In section it was found to consist largely of hornblende, which is in large irregular crystals and also in slender needles, embedded in the granular quartz-feldspar groundmass of the rock. The hornblende is strongly pleochroic in blue and brown tints,

suggesting a variety allied to glaucophane. Patches of the rock are wholly made up of granules of bright green epidote, which give a greenish mottling to the hand specimen. Cloudy areas full of minute black specks which may be magnetite are numerous. Numerous round or oval spots in the section, lined with quartz or feldspar and filled in with grains of calcite, strongly suggest amygdaloidal cavities in a lava; and it seems quite likely that the schist represents a completely metamorphosed eruptive rock.

In the canyon of Gold Creek immediately back of Juneau was found a series of greenstone schists of considerable extent. Of the many varying phases seen in this series the following varieties were collected:

No. 22, *actinolite-schist*, a very compact fine-grained schist of light green color, showing many slickensided surfaces covered with chlorite. In the section it is seen to be composed almost wholly of rather short prisms of actinolite, with quartz grains filling the interspaces. A little epidote in small grains and an occasional titanite grain are also present.

No. 23, *actinolite-schist*, very like the last, but charged throughout with minute and very sharp octahedrons of magnetite.

No. 341, *actinolite-schist*, the surface showing oval areas of chlorite, which give it a spotted appearance.

No. 25, *schistose diorite-porphyry* (actinolite-schist), a rock of schistose texture but distinctly porphyritic with white dots in the greenish matrix. Under the microscope the porphyritic spots appear as sharply marked areas containing aggregates of needles of zoisite and actinolite, with quartz filling the interspaces. The groundmass of the rock is a finely felted aggregate of actinolite needles with epidote and quartz grains. The appearance indicates pretty certainly the derivation of the rock from a diorite-porphyry by dynamic metamorphism.

In the schists are occasional quartz lenses in which are siderite and granular epidote and at times masses of fine scaly chlorite (delessite).

At one point on the road a dike of *aplite* was found,

about eight feet thick and parallel to the structure of the schist. The aplite has an indistinct schistosity parallel to its walls, and shows many films of sericite, doubtless formed during the shearing to which it has been subjected. The quartz and feldspar of which it is composed, partly in indistinct phenocrysts, show strain effects but little alteration in the thin section (NO. 27).

This series of greenstone schists, some of which at least are clearly derived from igneous rocks, is additional evidence of the correctness of Dawson's correlation of the black slate or argillite of Juneau with his Triassic Vancouver Series, which in the type locality also contains large bodies of metamorphic eruptives.

GEOLOGY ABOUT CHICHAGOF COVE

GEOLOGY ABOUT CHICHAGOF COVE, STEPOVAK BAY

WITH NOTES ON POPOF AND UNGA ISLANDS

BY CHARLES PALACHE

At Sand Point, in the Shumagin Islands, I left the steamer with a small hunting party. After spending a day on Popof Island, in the vicinity of Sand Point, the party was landed on the mainland of the Alaska Peninsula at a small cove on the shore of Stepovak Bay, known locally as Chichagof Cove. Here we remained for about ten days, and I had opportunity to study the geology of a limited area with some detail. In the following pages it is my purpose to record the observations I was able to make in the field and the results of the study of the rock specimens collected.

Unfavorable weather and limited facility for moving camp made it necessary to confine the study to a region within a short day's march from camp, and it was found impossible to traverse the peninsula—very narrow at this point—as I had hoped to do. Furthermore, I was without surveying instruments except for a small pocket compass, so that the map given herewith (fig. 16) is merely a sketch,

without any pretense to accuracy, intended only to show the general relative distribution of the various formations discovered.

VICINITY OF SAND POINT, POPOF ISLAND

Dall in his report on Coal and Lignite of Alaska[1] states that the northwestern part of Popof Island, near Sand Point, is composed of sandstones and conglomerates similar to those of the Kenai Formation in Coal Bay on the neighboring Unga Island. "They are broken and cut by dikes and larger intrusions of basaltic lava and diorite and near the contacts are much altered and intersected by veins of chalcedonic quartz."

I did not see this sedimentary formation. The point south of the harbor at Sand Point was visited, and seemed to be made up wholly of lavas and volcanic tuff; and similar rocks were found on the northern shore of the island at a bluff about three miles from Sand Point.

The lavas at Sand Point were found to be *augite-andesite* and *augite-hypersthene-andesite*. They are dark grey compact rocks showing glassy feldspar crystals in a dull groundmass. Under the microscope the structure is strongly porphyritic (slides 125, 126), the most abundant crystals being large fresh plagioclase feldspars with extinction angles of labradorite, abundantly twinned but very slightly zoned, and full of inclusions of glass. Augite, colorless or pinkish, is also present, but is largely altered to green serpentine. One slide (127) shows abundant hypersthene, sharply idiomorphic, with characteristic double refraction and faint pleochroism; some hypersthene crystals are enclosed in augite crystals in parallel position. The groundmass contains microlites of feldspar and augite in a glassy base.

Beneath the heavy masses of these very fresh lavas,

[1] 17th Ann. Rep. U. S. Geol. Survey, Pt. 1, p. 808. 1896.

which appeared to be surface flows, are coarse tuffs, very soft and rotten, containing kaolinized feldspar and biotite crystals as the only determinable constituents.

One of the members of a party which remained at Sand Point for some time collected large quantities of chalcedony from the beach a short distance from the harbor. He reported it very abundant in the low cliffs along the shore but brought no specimens of the rock in which the veins occur. This is probably the occurrence referred to by Dall (loc. cit.). The chalcedony is for the most part colorless or pale yellow, but a few pieces are a richly colored carnelian, and others are opaque from included greenish silicates (chlorite?). One specimen of yellow-brown jasp-opal was among those collected.

A visit was made to the Apollo gold mine on Unga Island, but we were unable to go underground in the few moments at our command, and the only rocks examined were those exposed at the landing place in Delarof Harbor. These are highly altered dacites and no facts were observed which add to the description of them given by Mr. Becker.[1]

One other rock specimen was brought aboard, said to come from the shore of Unga Island on the west side of the point opposite Sand Harbor. This is a banded *rhyolite*, grey in color and weathering buff with white bands. It is a very compact rock, and in section (128) shows little but an imperfectly granophyric intergrowth of quartz and feldspar with occasional magnetite grains. It is extremely similar in appearance to the rhyolite described (page 25) from near the Columbia Glacier in Prince William Sound.

STEPOVAK BAY, ALASKA PENINSULA

Stepovak Bay is a broad bay on the coast of the Alaska Peninsula a little east of north from the larger of the Shu-

[1] 18th Ann. Rep. U. S. Geol Survey. Pt. III, p. 55. 1898.

magin Islands. It indents the coast deeply, its waters being at one point within five miles of a branch of Port Moller on the northern side of the peninsula (see fig. 16). It would appear to have been little explored, the lack of coal-bearing strata on its shores and of large salmon streams emptying into it sufficiently accounting for the absence of reference to it in descriptions of this part of Alaska. Chichagof Cove, the point where our camp was located, is one of the smaller indentations of its shore, lying between two bold headlands which are tied together by a fine curving sand spit about a mile in length, breached at the centre and at the easternmost extremity, where small streams fall into the cove. It is marked on the accompanying map as the next to the last cove on the northern shore of Stepovak Bay, but the detail of the map is slight and this is not known with certainty to be the correct location. We were led to it by an Indian who told us of its name and that it was a good hunting ground, and as

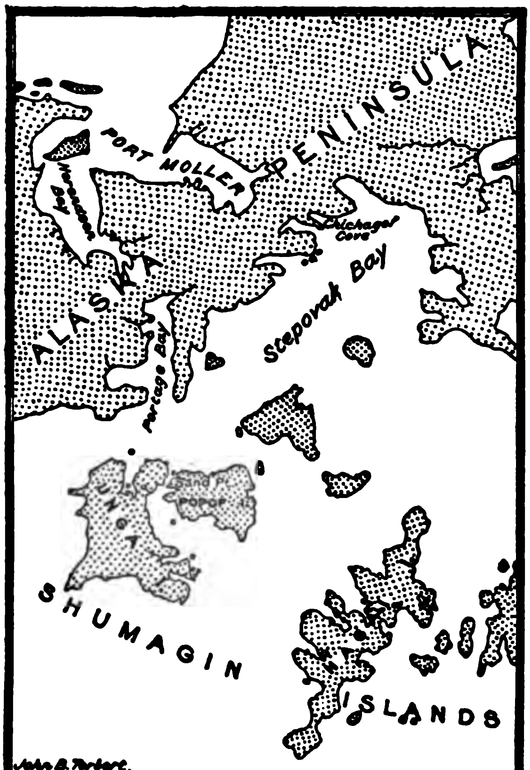


FIG. 16. MAP SHOWING POSITION OF STEPOVAK BAY AND CHICHAGOF COVE.
Scale, 1 inch = 30 miles.

the latter information proved to be incorrect the first may also well have been so.

Behind the sand spit and between the two ridges which terminate in East Point and West Point respectively, lies a broad flat valley, partly occupied by a shallow lake of brackish water subject to the ebb and flow of the tide, and partly by a level meadow which stretches back fully two miles from the sand spit. The hills rise abruptly and in places precipitately on all sides of the meadow, reaching at the highest point, called Chichagof Peak, an elevation estimated at not less than 3,000 feet. Several narrow V-shaped valleys open into the main valley from the east and several small streams cascade down the cliffs at its head.

The crest of the range was reached at but one point, a col directly behind Chichagof Peak. The summit here opens out to a plateau, broadening eastward and covered with snowfields, but to the north narrow and deeply dissected by streams flowing for the most part to the north. What seemed to be the waters of Port Moller were seen to the northwest, but of this I could not be quite sure.

West of Chichagof Valley and between it and the next deep cove to the west are four high and narrow ridges trending northwest, enclosing three small streams flowing southward.

The region is devoid of trees, but the lowlands are everywhere covered with a growth of high dense grass. Along the streams are willow thickets, and on many of the slopes are patches of low alder bushes. Above 1,000 feet elevation the vegetation is confined to scattering herbaceous plants, and the rocks are free from soil and well exposed. A curious feature of the talus slopes was observed on the gently sloping ridges near the upper limit of abundant grass growth. The ridge crests are minutely and quite regularly terraced, the terraces contouring the ridge

and dying out on either side slope. These terraces average about three feet in width, with two or two and a half feet rise between them; their surfaces are very level and paved with angular fragments of rock, not lying loose but firmly embedded in sandy material. The front slopes are densely covered with grass and other matted plant growth so that the appearance, looking up the slope, is of a continuous grassy covering, while looking down, all appears rocky and bare. The terraces often run from side to side of the slope without break, but again they anastomose like cow paths on a hillside. The downward shifting of the slide rock against the resistance of the matted plant covering would probably sufficiently account for the terrace structure, but the curiously even paved surface of the terraces was to me inexplicable.

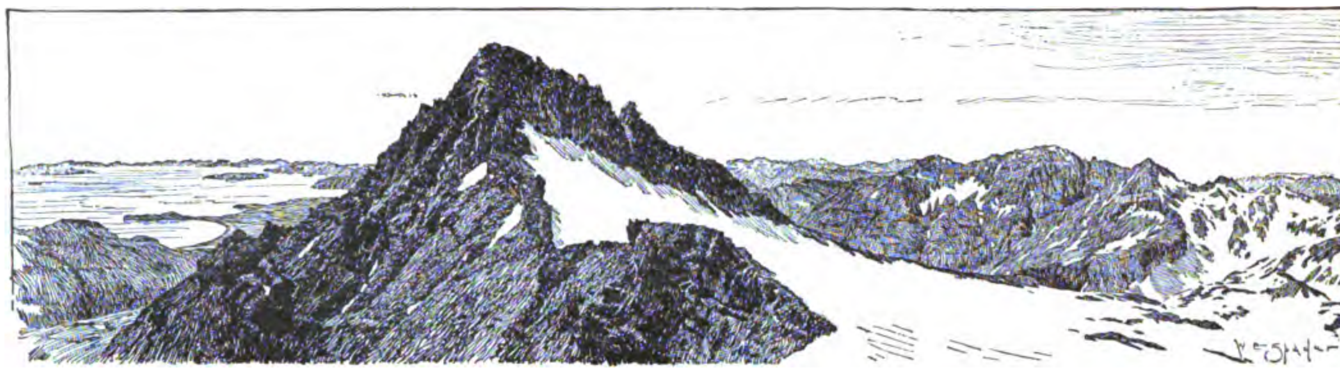
The summits of the higher peaks are angular and craggy, and nowhere was any evidence seen of glacial action even of a local nature.

The rocks occupying most of the area studied about Chichagof Cove (see fig. 17) are a series of marine sediments containing abundant fossil remains, which show them to be of Lower Eocene age. To this series the name Stepovak Series will be applied. The beds have been considerably folded and faulted, and invaded by a laccolithic intrusion of diorite-porphyrite, which sends off into the surrounding sediments numerous radial dikes of varying petrographic character.

THE STEPOVAK SERIES

The Stepovak Series may be divided on lithologic grounds into upper and lower beds.

The *lower beds* comprise coarse breccias or agglomerates and fine tuffs composed wholly of igneous material. They show only a rude stratification, but as far as it can be made out it is accordant with that of the overlying,



VIEW FROM CHICHAGOF PEAK

In the foreground is the highest pinnacle of the peak; at right (west) the mountain ranges of Alaska Peninsula; at left (south) Stepovak Bay and Chichagof Cove. See page 73. From photographs by Charles Palache.

distinctly bedded sediments. The coarser agglomerates contain angular fragments, a foot or less in diameter, of white or greenish porphyry and, rarely, granite. These are cemented sometimes by comminuted material of

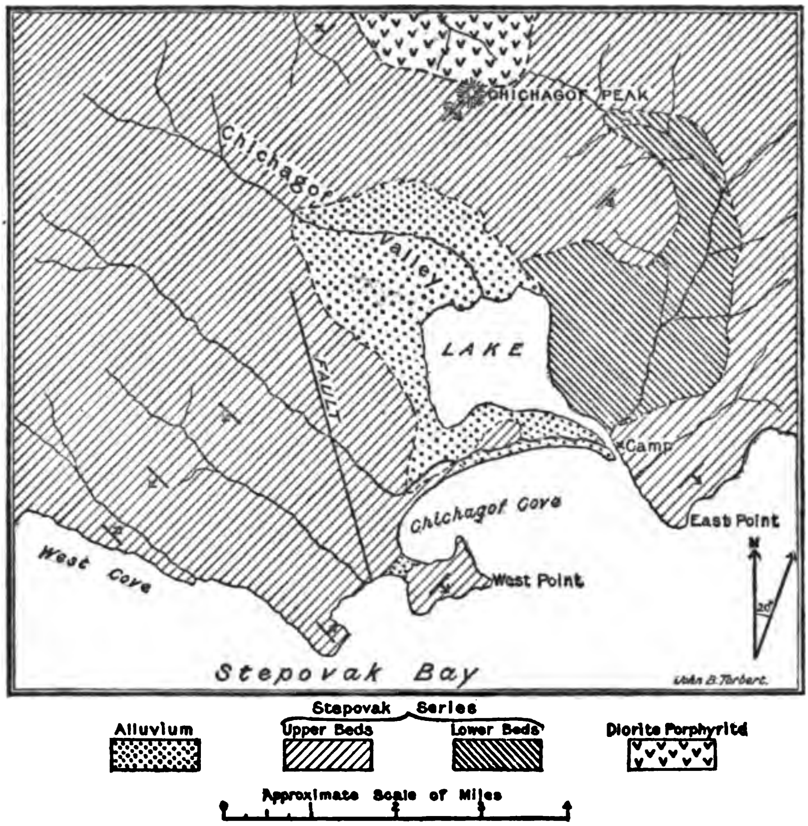


FIG. 17. GEOLOGICAL SKETCH MAP OF THE VICINITY OF CHICHAGOF COVE, ALASKA PENINSULA.
By Charles Palache.

the same nature, sometimes by a dark greenish black compact material which is found, under the microscope, to consist essentially of interwoven hornblende needles. The finer-grained tuffs have a most varied appearance. One specimen is a mass of small angular fragments of

yellowish porphyry, the interspaces, largely unfilled, giving the rock a cellular appearance. Again the tuff is compact, with small fragments well cemented. In places the rock is stained bright green by disseminated iron silicates (celadonite?). The impression of these rocks as brought from the field was that they were made up of material of widely varying character. But microscopic study does not confirm this impression. On the contrary, they show in all their phases, and whether the fragments of which they are composed be large or small, considerable uniformity in petrographic character. Most of the sections (Nos. 115 to 124) show porphyritic rocks with a glassy groundmass or with one so indistinctly crystalline as to suggest a devitrified glass. Occasionally the groundmass is a fine granophyric intergrowth of quartz and orthoclase. The numerous phenocrysts consist of acid plagioclase, less abundant orthoclase, and deeply embayed quartz crystals. The feldspars are very fresh and free from inclusions. Magnetite in minute grains seems to be the only other constituent of the rock. The rock fragments seen in the sections range in character from rhyolite to dacite-porphyry, with an occasional one of granite.

The cement which binds the fragments together is in some cases clearly secondary silica, but more generally appears to be glass, in which are carried minute feldspar fragments and crystals of quartz, portions of spherulites, and occasionally sharp crystals of zircon and apatite. In one specimen, as mentioned above, the cement is a mass of felted hornblende crystals.

The pyroclastic character of these rocks is certain; in some there is slight evidence of water sorting; others may fairly be called flow breccias. To my surprise some of them were found to contain fossil shells, for the most part of a pecten-like form. These fossils are too poorly preserved and too few to furnish any basis of age com-

parison with those found in the higher beds. But they establish the fact that some of the tuffs at least are water-laid deposits, however little the rocks themselves might suggest that conclusion.

The *upper beds* consist of soft shales, sandstones and grits, with some thin beds of limestone and now and then a chert band. They are the principal rocks of the region, and make up the whole coast line of the area studied. The following sections of these beds were noted, and will serve to indicate the character of the rocks in different portions of the area.

GEOLOGICAL SECTIONS

East Point of Chichagof Cove.—Strike N 65° E (true), dip S 25° E, about 45°. Dip uniform through the whole section. Alternating bands of soft black shale and fine-grained sandstone, the shale more abundant in the lower part of the section. One bed of coarse grit, but no conglomerate. Some of the shale is reddish from abundant limonite, and both shale and sandstone in certain layers include small limestone concretions, rarely containing fossils. The fossils are chiefly casts in massive beds of sandstone occurring in the upper part of the section. On exposed surfaces the sandstone breaks up into lenticular masses with uneven, curved parting surfaces. The section was not measured, but was estimated at not less than 1,000 feet in thickness.

West Point of Chichagof Cove.—Strike N 80° E, dip S 10° E about 20°, flattening a little to the west. The base of the section is of soft shale, some layers containing limestone concretions, others sparse pyrite nodules. Above these are heavy-bedded sandstones, gray to greenish gray in color, with numerous, rather scattered fossils. In some places the sandstone is full of concretions, from three inches to one foot in diameter, which were not found to contain fossils.

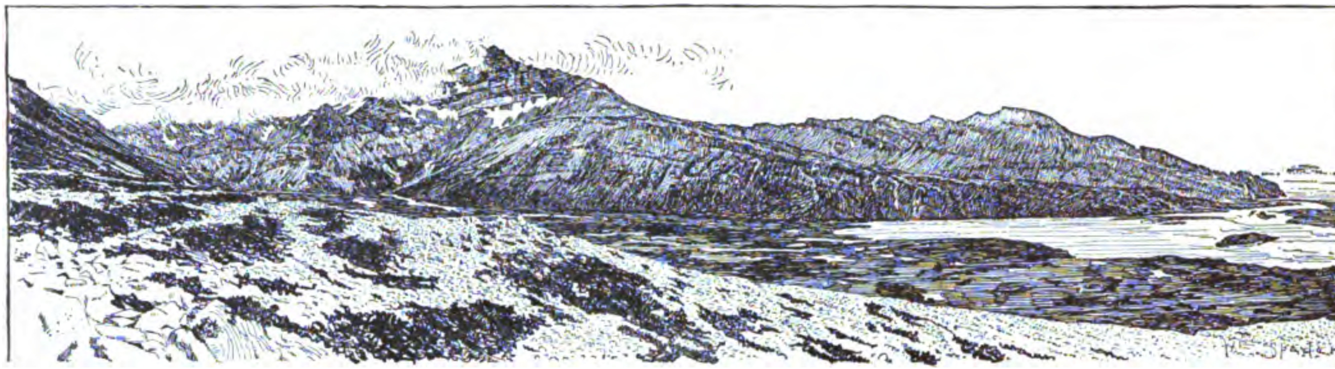
Chichagof Peak.—Resting on the lower pyroclastic beds at the base of the mountain is a considerable thickness of soft black shale containing a few fossils; near the contact of the dikes which cut it, it is baked and silicified. Above the shale is cross-bedded sandstone, highly silicified, in which no fossils were discovered. Above this are beds of rusty red shale, with occasional layers of sandstone, to the sum-

mit. The beds are almost horizontal in this section, and the thickness, from the top of the lower beds, was estimated at about 1,200 feet.

The rocks of the Stepovak Series have been folded and faulted. Plate VIII shows the broad domal uplift which is magnificently exposed on the eastern wall of Chichagof Valley. From Chichagof Peak, in which the beds are practically horizontal, and beneath which, as will be shown below, is an extensive laccolithic intrusion, the strata dip away on all sides, with gradually increasing inclination, reaching 45° at East Point, which is about five miles from the peak. This doming up of the strata was accompanied by minor faulting and by the formation of fissures or lines of weakness, roughly radial to the dome, into which the igneous rock made its way in the form of dikes.

The attitude of the rocks has controlled the development of the drainage in very marked manner. The streams follow the strike of the beds, working down along the soft shale horizons; the southward facing sides of the valleys have gentle dip slopes; the northward facing sides are steep, often precipitous, scarps formed by the harder sandstones.

As far as West Point the dome structure controls the attitude of the beds. Beyond this point, and west of a line running a little west of north from it, there is an abrupt change of the strike through an angle of 90°, so that the beds strike nearly parallel to the shore of West Cove and dip northeast at angles never exceeding 30°. It appeared in the field that this abrupt change of strike could only be due to a north-south fault of considerable extent, but the character of the exposures in the course of this probable fault was unfavorable to its direct observation. In traversing the ridges from the head of West Cove to Chichagof Valley, the strike of the rocks was found to be persistently about northwest, and the streams to follow the strike closely in direction. But the dip changes from northeast to southwest after passing the



CHICHAGOF PEAK

The view is panoramic from a point at the southeast. The anticlinal or dome structure of the rocks (p. 78) is shown. At right is a tidal lake, tributary to Chichagof Cove; in the foreground are examples of the terraced slopes described at page 73. From photographs by Charles Palache.

second ridge, giving a synclinal structure to this part of the area.

Concerning the fossils collected from this formation, Dr. Dall, to whom they were submitted for study, says: "The fossils from the Stepovak beds are Eocene, probably of about Claiborne age (middle Eocene), and the only typical Eocene yet discovered in Alaska." The description of these fossils by Dr. Dall and a discussion of the place of the Stepovak Series in the Alaska geological column will be found elsewhere in this volume.

THE IGNEOUS ROCKS

The Laccolith

The intrusive rocks which have invaded the beds of the Stepovak Series are in the form of numerous dikes and a large laccolithic mass from which the dikes appear to radiate. The laccolith is well exposed near the summit of Chichagof Peak on the eastern side, the only point of the crest of the plateau which was reached. The diagrammatic section, fig. 18, shows the relations that could there be observed. A general view to the north from the summit of the mountain gave the impression that the igneous rocks formed an extensive mass, the observed section lying on its extreme southeastern periphery, and therefore giving an inadequate idea of the bulk of the intrusive matter as compared with the sedimentary rocks.

The material of the laccolith is chiefly diorite-porphyrite, with small amounts of augite-diorite-porphyrite. It is a dark-colored rock, grey to greenish grey, and rather fine-grained, with distinctly prophyritic texture. On weathered surfaces the phenocrysts of hornblende stand out in relief and give the rock a very rough surface. The characteristics of the rock in its various phases may best be learned from the descriptions which follow of particular specimens.

No. 80. *Diorite-porphyrite.* Greyish green rock with many stout prismatic green hornblende crystals, in fine grey matrix, which stand out on weathered surface. Groundmass of minute green hornblende needles and basic plagioclase microlites less in amount. Phenocrysts labradorite and hornblende. Labradorite very abundant in sharply bounded crystals, twinned on albite and Carlsbad laws, very fresh and free from inclusions. Hornblende colorless to pale green, fibrous, in short stout sharply terminated crystals, sometimes enclosing a small core of colorless pyroxene, but clearly original. Chlorite almost the only decomposition product, replacing some of the groundmass hornblende. Quartz is absent.

No. 88. *Diorite-porphyrite.* Dark grey rock, porphyritic, with crystals of green hornblende and glassy feldspar visible. Groundmass composed of about equal amounts of fibrous hornblende and plagioclase laths (labradorite), with grains of magnetite. Phenocrysts acid labradorite in sharp crystals with rather abundant inclusions of chlorite (alteration of hornblende?), and short prisms of almost colorless hornblende containing rather large cores of diopside. Hornblende sometimes entirely altered to chlorite, in which are numerous needles of bluish secondary hornblende.

No. 89. *Diorite-porphyrite.* Greyish spotted rock, porphyritic, showing many white feldspars and dark hornblende prisms. Very little groundmass, consisting wholly of green needles of hornblende and magnetite grains. The feldspar is acid labradorite and is all in sharply idiomorphic phenocrysts complexly twinned on albite law and but little zoned. Some phenocrysts of green pleochroic hornblende devoid of pyroxene cores. Much secondary chlorite and with it needles of the same bluish hornblende seen in no. 88.

No. 87. *Augite-diorite-porphyrite.* Grey-green porphyry, showing white feldspar and black augite phenocrysts, rather abundant. Groundmass consists of labradorite feldspar microlites and hornblende needles, often however wholly replaced by chlorite. Magnetite is abundant and much of it concentrated in zones about areas of chlorite, as though set free during the alteration of hornblende or augite. Phenocrysts, feldspar and augite. The feldspar is oligoclase to acid labradorite, cloudy with decomposition products, abundant, making up about one-half of the rock. Augite colorless, idiomorphic, much twinned, and often changed to chlorite but not to hornblende.

Nos. 83, 84 and 85. *Diorite-porphyrite breccia.* Mottled greenish porphyry rather coarsely brecciated, some fragments being darker in

color than the mass. The rocks are much altered, the groundmass largely to chlorite and bluish fibrous hornblende, the hornblende phenocrysts to the same, with separation of magnetite grains on the borders. The feldspar is cloudy with kaolin and indeterminable. Some of the dark fragments prove to be aggregates of tourmaline needles, others are more basic portions of the diorite-porphyrite. These are apparently friction breccias formed near the border of the intrusion.

The Dikes

Dikes cutting the sedimentary rocks are found in all parts of the area studied but are especially numerous in the vicinity of the laccolithic mass. They are never of very great dimensions; a few reach a thickness of about twenty feet, but those from four to ten feet in width are most frequent. Their linear extent is rarely more than a few hundred feet, although one was found which could be traced continuously about half a mile. The dike rocks, being in general much more resistant than the shales and sandstones which they traverse, stand up in bold walls,

FIG. 18. DIAGRAMMATIC SECTION ON SOUTH FACE OF CHICHAGOF PEAK.

sometimes fifteen or twenty feet high, as shown in the annexed sketch (fig. 18); and on the shore they generally stand out as prominent cliffs.

The dikes have not been indicated on the sketch map. In a general way they are radial to the dome-shaped uplift of Chichagof Peak, and hence for the most part cut across the strike of the sedimentary beds at high angles. This was strikingly the case with the dozen or more dikes found along the shore of West Cove, all of which are

nearly vertical and at right angles to the strike of the sandstones, appearing to follow the direction of their dominant jointing.

The dike rocks vary widely in petrographic character, and in the absence of chemical analyses can not always be classified satisfactorily. Certain types of rock were found, however, to be persistent, and descriptions of these will perhaps give an adequate idea of the intrusive bodies.

ALKALI-SYENITE-PORPHYRY

Several dikes of an alkaline hornblendic porphyry were found, and as they are in appearance the most striking rocks collected, and have proved to be the most interesting petrographically, they will be described first.

Nos. 78, 98 and 99 are from three similar dikes about six feet in width, cutting vertically the lower Stepovak beds near the western foot of Chichagof Peak. They are abundantly porphyritic rocks, with numerous shining black hornblende crystals in a compact greyish to buff-colored groundmass. The hornblende crystals are as much as half an inch in length, slender, bounded by planes of prism and pinacoids, 110, 100, and 010, and showing very perfect prismatic cleavage. They may sometimes be seen to surround a core of a lighter green mineral which proved to be diopside.

Rather numerous small irregular cavities occurring in the rock are lined with bright green crystals of epidote and sometimes are filled with granular quartz. The weathered rock develops a platy parting parallel to the dike walls, and the groundmass becomes soft and crumbly, showing cavities filled with fibrous masses of laumontite.

In thin section the groundmass proved to consist chiefly of minute feathery crystals of feldspar showing over considerable areas a rude parallelism of their longer dimensions. The feldspar has a lower index of refraction than the balsam, and is rather obscurely twinned on the albite law, with somewhat wavy extinctions at low angles. These characters point to albite or an acid oligoclase. With the feldspar are numerous grains and tiny prisms of colorless diopside, abundant magnetite grains, and here and there a needle of pale green secondary hornblende. In one section an insignificant amount of quartz was found in the groundmass, but it is generally lacking. The pheno-

crysts are chiefly hornblende, strongly pleochroic, light brown to pale yellow, frequently twinned. In several cases cores of colorless diopside are enclosed by the hornblende in parallel position, the boundaries between them irregular but sharply marked. The hornblende is clearly original. Epidote in grains and short prisms filling cavities of irregular shape is present in all the slides.

The rock is a *hornblende-alkali-syenite-porphyry*.

In NO. 98 the groundmass is somewhat coarser, and in addition to the hornblende phenocrysts are a few ill-defined feldspars which appear to have the composition of oligoclase. Careful search of the slides for nepheline failed to reveal its presence.

Nos. 95, 96, 97, 100, 101 and 102 are specimens from different parts of the same dike, which outcrops on the shore of Stepovak Bay at East Point with a width of ten feet, and again a half mile to the north in a gulch near the camp, where it is six feet wide. The dike is nearly vertical, and its general course is about at right angles to the sedimentary rocks which it cuts, but in the gulch it turns abruptly into the strike of the beds, and was followed some distance as a sill. The rock is dull grey in color, fine-grained and compact near the walls of the dike, but coarser at the centre and slightly amygdaloidal, the cavities filled with fibrous laumontite and calcite. Prisms of black hornblende are sparingly present through its whole mass, here and there aggregated to radial groups. Isolated glassy feldspars are also visible.

In thin section the groundmass is seen to be entirely similar to that of the last rock, consisting of laths of albite and grains of augite and magnetite. The phenocrysts are very slender prisms of hornblende, anhedra of diopside and occasional anhedra of albite. They are few in number, however, compared with the phenocrysts of hornblende of the first rock described, and herein consists the principal difference between the two rocks.

No. 81. This rock is from a dike cutting the shales on the lower slopes of Chichagof Peak. It is rather coarsely granular, of a greenish-grey color, and appears to the eye to be in an advanced stage of alteration. In thin section it appears quite fresh, however, and is found to be holocrystalline and almost ophitic in structure. It is composed of a network of laths of plagioclase feldspar, varying in composition from albite to acid oligoclase, with which are numerous larger anhedra of orthoclase, determined by their lower refractive index and lack of twinning. The interspaces of the feldspars are occupied by grains of colorless pyroxene (diopside) partly altered to serpentine,

together with fairly abundant magnetite. The rock differs materially from the preceding alkali-syenite-porphyries, both in structure and in the absence of hornblende, but it is nevertheless, though with some doubt, classed with them.

Many other dikes, from which specimens were not collected, appeared to consist of rocks similar to those just described, so that the characteristic dike rock of the region may be considered an alkali-syenite-porphyry.

LATITE

No. 94. On the lower slope of Chichagof Peak, just above the little lake, and cutting the lower Stepovak beds (breccias), is a narrow dike of a black glassy-looking rock, weathering into spheroidal forms. Glassy feldspar phenocrysts are abundant in the aphanitic groundmass. Studied in thin section, this rock proved to be wonderfully fresh and lava-like in appearance. In a groundmass of brown glass crowded with microlites of plagioclase feldspar and augite, are numerous phenocrysts of labradorite, orthoclase and augite. The smallest feldspar microlites seemed to have the same character as the most abundant phenocrysts, which were determined as basic labradorite by extinctions of complex albite-Carlsbad twins. The phenocrysts contain numerous inclusions of glass, which are grouped parallel to the outlines of the crystal and are in part altered to chlorite. But the feldspar itself appears perfectly fresh and unaltered.

The orthoclase, which is less abundant than the labradorite, offers many points of interest. It is in anhedra with subangular and often rounded and deeply embayed outlines. Some are quite unaltered; more frequently the whole centre of the crystal is granulated, the grains of orthoclase showing wavy extinctions, the border also orthoclase, but in a single individual with uniform extinction throughout; again, with the same orthoclase border as in the last, the centre is occupied wholly by fibrous chlorite, and in a final stage the chlorite occupies the whole space. In some crystals the granular orthoclase and the chlorite are intermingled with grains of augite, and it appears as if the chlorite were derived from the decomposition of the augite. But there must also have been replacement of feldspar substance by chlorite in the largely or wholly chloritized crystals. The embayed outline of the orthoclase crystals suggests that they were the first separation from a magma which afterwards attacked them, in part dissolving, in part

granulating the mass of the crystal. Thus weakened in structure, the crystals have been peculiarly subject to the attack of decomposition, and have been largely replaced by chlorite, derived in part from augite inclusions in the orthoclase, in part from the groundmass of the rock.

The augite is in sharply-bounded short prisms, showing octagonal cross-sections. It is colorless, and in some cases is in process of alteration to chlorite. Magnetite grains are sparingly present.

The presence in this rock of orthoclase, together with a basic plagioclase and augite, places it in the latite series, intermediate to trachyte and andesite. Without a chemical analysis it is difficult to define the type more closely, but in its mineralogical composition it would appear to stand near *vulsinite*.

No. 92. A rock from a four-foot dike cutting across the shales of West Point, Chichagof Cove, appears to be allied in composition to the foregoing. It is a greenish rock of very fine and even texture, slightly amygdaloidal in the centre of the dike. Under the microscope it is seen to be sparingly porphyritic, with small, ill-defined anhedra of augite, andesine feldspar and apparently orthoclase in a pilotaxitic groundmass made up of plagioclase laths, apparently andesine, and grains of augite and magnetite. The feldspar phenocrysts, especially those which from their low refractive index and the absence of twinning were determined as orthoclase, enclose centres of chlorite in the manner described in the last rock, but the appearance is less striking, owing to their much smaller size.

HORNBLENDE-DACITE

No. 93. This, the only dacite found in this region, was observed only as a boulder in the bed of a small stream draining into West Cove from a region occupied mainly by sedimentary rocks. It probably comes from a dike traversing those rocks. It is a light-colored porphyry with abundant phenocrysts of hornblende, snowy plagioclase and quartz, and occasional flakes of biotite and crystals of pyrite. The hornblende is in long slender crystals, pleochroic, pale brown to bluish green. It is often largely altered to chlorite. The feldspars are mostly large, sharply idiomorphic, complexly twinned and zoned crystals, which give extinctions showing a range from oligoclase to labradorite. There are also occasional crystals of orthoclase. The quartz is in deeply embayed bipyramidal crystals. Biotite was not observed in the section. These phenocrysts are embedded in a fine-grained groundmass, consisting of quartz and orthoclase in micropeg-

matitic intergrowths, laths of acid plagioclase and a little diopside in grains.

DIORITE-APLITE

No. 86, forming a dike twenty feet wide, which stands out as a prominent wall in the shales on the upper slopes of Chichagof Peak, is a very compact grey rock showing minute glassy feldspar phenocrysts and rather abundant though small pyrite crystals. Under the microscope it was found to consist almost wholly of triclinic feldspar. The phenocrysts, which are sparse, are highly twinned albite crystals. There are also occasional pseudomorphs of calcite after what seems to have been hornblende. The groundmass is a network of lath-shaped crystals of oligoclose, in the minute interspaces of which is calcite, and chlorite which may represent original pyroxene, although no unaltered pyroxene could be found. Magnetite and pyrite are sparingly present and several apatite needles were noted.

No. 110, from a narrow dike on the shore of West Cove, is similar in character to the foregoing, but contains biotite and small amounts of pyroxene in the feldspathic groundmass.

These rocks seem best classified as diorite-aplites, occurring as they do in connection with an intrusive mass of dioritic nature.

DIORITE-PORPHYRITE

No. 82. Near the summit of Chichagof Peak, on the east side, a large dike, about thirty feet in width and conspicuous by its light color, cuts both the sedimentaries and the diorite-porphyrite intrusive in them (see fig. 18). The rock constituting this dike is a porphyry of rather fine grain with numerous dark green hornblende and snowy plagioclase crystals in a compact greenish groundmass. The feldspars predominate, giving the rock as a whole a light grey color. In thin section it was found to consist of phenocrysts of labradorite and hornblende in a groundmass of albite, hornblende, colorless pyroxene and accessory magnetite and titanite.

The labradorite was determined as such by extinctions on the sharply idiomorphic albite-Carlsbad twins. It is abundant, making up perhaps a third of the rock.

The hornblende is in slender prisms with fringed-out ends, and is weakly pleochroic, green to brown in pale tints. It is not abundant, and is sometimes wholly altered to chlorite.

The groundmass is a finely interwoven aggregate of albite laths with faintly green hornblende needles, some or all of which may be

secondary. Pyroxene is very sparingly present, in colorless grains, and is also much altered to chlorite.

The rock is more feldspathic and certainly more alkaline than the diorite-porphyrites which it cuts; though it is here placed in the same class with them, it may be more nearly related to the monzonites. The chemical analysis necessary to determine this has not been made.

No. 112 is from a narrow dike on the shore of West Cove. It is similar to the last, but somewhat less porphyritic, and has suffered much alteration, so that the nature of the original bisilicate is in doubt, although it appears to have been hornblende. The feldspars, so far as they could be determined, are the same as in the preceding.

Many other dikes of much the same appearance as No. 82 were seen, from which no specimens were collected. It is one of the prominent types of dike rock in the region.

OLIVINE-DIABASE AND DIABASE-PORPHYRITE

A number of the dikes along the shore of West Cove proved to consist of rocks more basic in character than those so far described, having the composition and structure of diabase and diabase-porphyrite.

No. 103 is the freshest and most characteristic of these rocks. It is from a narrow dike, the first encountered in going northwest along the shore from West Point. It is a heavy dark green rock, rather coarsely granular, and traversed by many slickensided surfaces coated with chlorite, which give it an appearance of advanced decomposition. In the thin section it proves, however, to be much less altered than its outward appearance would indicate. It is strikingly ophitic in structure, the principal constituents being lath-shaped crystals of basic labradorite and large patches of violet-colored augite, allotriomorphic to the feldspar. Other constituents are ilmenite and small amounts of biotite. Secondary products are calcite and sericite, replacing wholly or in part the feldspar; chlorite derived from the augite; abundant bright green serpentine in patches whose form suggests a derivation from olivine (a suggestion confirmed by the borders of magnetite grains surrounding some of the patches); and leucoxene bordering or wholly replacing the ilmenite crystals. The feldspar is cloudy with decomposition products, but its extinctions are still distinct enough to permit its determination. The augite is for the most part very fresh, and only in one or two spots could it be seen to pass into chlorite; its color, taken with the presence of ilmenite in the slide, suggests that the augite is titaniferous.

The rock has the characters of a typical *olivine diabase.*

No. 109, from a narrow dike farther along the shore, is extremely similar to the preceding, but with fresher feldspars, more abundant serpentine in the form of olivine, and with the augite largely altered to calcite with separation of abundant magnetite.

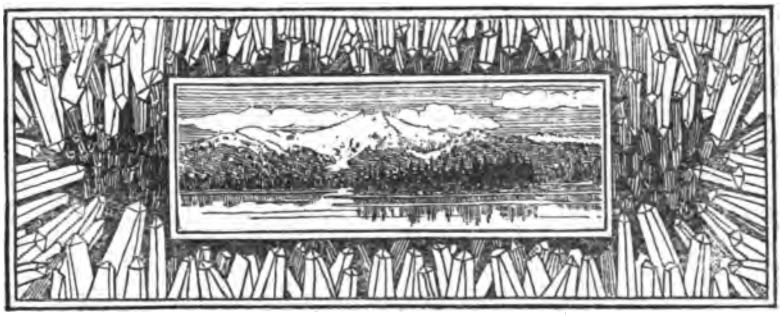
Nos. 107 and 108 answer to the same description, but are almost wholly decomposed, with formation of abundant calcite. At the contact of No. 107 with the sandstone, however, the rock is better preserved and shows very fresh small porphyritic feldspars with angles of extinction on albite twins determining them as bytownite. The groundmass is a minutely fine-grained aggregate of plagioclase needles and augite and magnetite grains.

No. 104 is from a dike twenty to thirty feet wide which stands out as a bold cliff on the shore. The dike contains many inclusions of shale, and has baked the shales which it cuts at the contact. It is a coarse-grained grey rock, differing from the preceding in the absence of serpentine and in the abundance of uralitic hornblende, which may be seen fringing the augite crystals from which it is derived. The feldspar is basic but largely decomposed. Ilmenite is abundant in parallel groups of platy crystals. The rock may be described as *uralite-diabase.*

No. 113 differs from the previously described diabases chiefly in structure. It is from a dike near the head of West Cove, and is a dark-green rock with porphyritic crystals of green augite and patches of green-black serpentine in an aphanitic groundmass. In thin section the augite is seen to be sharply idiomorphic and of a violet tint. It is quite fresh. There are occasional phenocrysts of labradorite feldspar, and the serpentine patches are in the form of olivine crystals and very numerous. The groundmass is minutely ophitic and composed of labradorite laths and grains of augite and an abundant iron ore, judged to be ilmenite from the grey leucoxene surrounding some of the grains. The rock may be called an *olivine-diabase-porphyrite.*

No. 79, from a sill in the shales at the head of the gulch back of the camp, is somewhat similar to the last. It, however, lacks the abundant serpentine pseudomorphs after olivine, and is a more feldspathic rock, with numerous labradorite and sparse augite phenocrysts in an ophitic groundmass of labradorite laths and augite grains. The latter have been largely altered to calcite. This rock may be termed a *diabase-porphyrite.*

MINERALS



MINERALS

NOTES ON THE MINERALS COLLECTED

BY CHARLES PALACHE

THE mineralogical collections of the party were not extensive, and most of the minerals found have already been mentioned in the preceding papers. A few localities deserve somewhat more detailed description than has been given them, and it has seemed worth while to bring together in the form of a catalogue the minerals found and their localities.

At Lowe Inlet, B. C., a party of miners was met who had specimens of copper ores which they said came from Banks Island, B. C., from a broad quartz vein traversing granite. The ores consist of massive pyrrhotite, with chalcopyrite and pyrite in a gangue of quartz, and some calcite; in some specimens the copper minerals are embedded in masses of coarse fibrous actinolite, and in others actinolite and massive garnet are embedded in the calcite, with sharp pyrite crystals. Some of the smaller crystals of pyrite are very brilliant and proved to be unusually

complex in their forms. They are combinations of the cube (100), the pyritohedron (210), and the octahedron (111), with the less common forms n(211) and m(311), trapezohedrons, and occasional planes of the diploids Σ(532) and Z(531). The form n especially was well developed with quite large planes.

The occurrence of rhodonite has been noted (page 46) at the Chicago mine, Silver Bay, near Sitka. As this mineral has not before been reported from Alaska, it may be well to describe the occurrence in more detail. The rhodonite occurs in massive aggregates of short prismatic grains large enough to show the cleavage distinctly on the fractured surface. The color is pale pink and is emphasized by the black stain of manganese oxide, as is so often the case with this mineral. The rhodonite forms a considerable portion of the vein-filling, in masses, up to a foot in diameter, of nearly pure material, but the color is too pale to give it value as a decorative stone, though its texture is well suited for polishing. It is often traversed by veins of calcite, and the microscope shows that more or less quartz is intermixed with it, even where it looks pure.

Near the Treadwell mine, Douglas Island, several narrow veins of albite and dolomite were found traversing the diorite. The albite is in small glassy crystals, some of which proved to be measurable on the goniometer. The crystals are simple twins on the albite law and show the following forms: M(010), P(001), l(110), T$(1\bar{1}0)$, z$(1\bar{3}0)$, f(130), x$(\bar{1}01)$, r$(\bar{4}03)$, o$(\bar{1}\bar{1}1)$, δ$(\bar{1}\bar{1}2)$. These veins are of secondary origin, and the albite is probably simply a recrystallization of the albite forming the predominant mineral in the diorite.

Laumontite occurs abundantly in portions of the great trachyte body of St. Matthew Island (page 33). It is found with calcite and stilbite, filling or lining fissures

and cavities in the rock. Calcite was the first and the last mineral to be deposited in these cavities. The earlier deposit is in granular form, the later in distinct crystals, some of them half an inch in length, showing combinations of the forms M(40$\bar{4}$1), f(02$\bar{2}$1), and L(08$\bar{8}$7); the first two have bright reflecting planes but the negative rhombohedron (L) forms a somewhat rounded, dull termination. Stilbite forms drusy coatings of characteristic platy crystals, showing the ordinary forms. The laumontite, which is the most abundant mineral, is in fibrous masses or single acicular crystals of pale pink color, showing square cross-section and an inclined terminal plane where they project into an open cavity. The crystals are not measurable, but the mineral was certainly determined by its crumbling character, its form and its chemical behavior.

In describing the syenite-porphyry of Stepovak Bay (page 82), mention was made of small cavities filled with epidote. The crystals are minute but they are sharply formed and prove to be measurable. The following forms are found: c(001), b(010), a(100), e(101), i($\bar{1}$02), r($\bar{1}$01), o(011), n($\bar{1}$11), and y($\bar{2}$11). The crystals are prismatic parallel to the axis $\bar{b}$, and are terminated by a broad plane of b with extremely narrow faces of o, n, and y about it.

In another phase of this porphyry the amygdules are filled with finely fibrous laumontite and a core of calcite, and in one of the cavities the calcite forms a distinct and measurable crystal, a combination of M(40$\bar{4}$1) and f(02$\bar{2}$1) with rather rounded faces of the scalenohedron T(53$\bar{8}$2).

In the following catalogue of the minerals found by the Harriman Expedition, rock-forming minerals are excluded except in one or two cases where the mineral was unusual or of eminent size or striking character.

Catalogue of Minerals

Mineral.	*Occurrence.*	*Locality.*
Actinolite	In schist	Gold Creek, Juneau.
	Pegmatite boulder	Shore of Yakutat Bay.
	With copper ore	Banks Island, B. C.
Amethyst	In lava	Hall Island, Bering Sea.
Asbestos (chrysotile)	In serpentine	Treadwell mine, Douglas Id.
Albite	Vein in diorite	" " "
Arsenopyrite	In quartz vein	Uyak Bay, Kadiak Island.
Calcite (crystals)	In lava	St. Matthew Id., Bering Sea.
	In porphyrite	Stepovak Bay.
Chalcedony	In lava	Hall Island, Bering Sea.
	"	Popof Island.
Chalcopyrite	In copper ore	Banks Island, B. C.
	In gold ore	Treadwell mine, Douglas Id.
	In copper ore	Landlocked Bay, Prince William Sound.
	" "	Virgin Bay, Prince William Sound.
	" "	Latouche Island, Prince William Sound.
	In gold ore	Apollo mine, Unga Island.
Dolomite	Vein in diorite	Treadwell mine, Douglas Id.
Epidote	Cavities in porphyrite	Stepovak Bay.
	Veins in granite	Sturgeon Bay, Kadiak Id.
	Veins in schist	Gold Creek, Juneau.
Galena		Landlocked Bay, Prince William Sound.
		Apollo mine, Unga Island.
Garnet	In aplite	Lowe Inlet, B. C.
	In limestone	Reid Glacier, Glacier Bay.
	Limestone boulder	Hugh Miller Inlet, Glacier Bay.
Garnet	In copper ore	Banks Island, B. C.
	In gneiss	Farragut Bay.
Glaucophane	In quartz-schist	Moraine, Hubbard Glacier, Yakutat Bay.

Mineral.	*Occurrence.*	*Locality.*
Glaucophane ?	In schist	Juneau.
Gold	Gold ore	Treadwell mine, Douglas Id.
Graphite	"	" " "
Hornblende	Porphyritic diorite	Hugh Miller Inlet, Glacier Bay.
	In porphyrite	Stepovak Bay.
Jasper	Radiolarian chert	Halibut Cove, Cook Inlet.
	Boulder	Hall Island, Bering Sea.
Laumontite	In lava	St. Matthew Id., Bering Sea.
	"	Stepovak Bay.
Magnetite	In aplite	Lowe Inlet, B. C.
	In actinolite-schist	Gold Creek, Juneau.
Pyrite	In gold ore	Treadwell mine, Douglas Id.
	"	Cordova Bay, Prince William Sound.
	"	Apollo mine, Unga Island.
	"	Chicago mine, Baranof Id.
	In copper ore	Banks Island, B. C.
	"	Virgin Bay, Prince William Sound.
	"	Landlocked Bay, Prince William Sound.
	"	Latouche Id., Prince William Sound.
	"	Seldovia, Cook Inlet.
	"	Port Graham, Cook Inlet.
	In slate	Kadiak.
	"	Port Clarence.
Pyrrhotite	In copper ore	Banks Island, B. C.
	"	Landlocked Bay, Prince William Sound.
	"	Latouche Island, Prince William Sound.
	"	Seldovia, Cook Inlet.
	In quartz vein	Near Muir Glacier, Glacier Bay.
	"	Chicago mine, Baranof Island.
Pyroxene	In limestone	Reid Glacier, Glacier Bay.
Rhodochrosite	In gold ore	Mexican mine, Douglas Id.
Rhodonite	In gold ore	Chicago mine, Baranof Id.
Siderite	In quartz vein	Treadwell mine, Douglas Id.
	"	Gold Creek, Juneau.

Mineral.	*Occurrence.*	*Locality.*
Silicified wood	In tuff	Unga Island
Sphalerite	In copper ore	Landlocked Bay, Prince William Sound.
	"	Virgin Bay, Prince William Sound.
	"	Latouche Id., Prince William Sound.
Sphalerite	In copper ore	Banks Island, B. C.
	In gold ore	Apollo mine, Unga Island.
	"	Cordova Bay, Prince William Sound.
Staurolite	In mica schist (boulder)	Hugh Miller Inlet, Glacier Bay.
Tremolite	In limestone	Reid Glacier, Glacier Bay.
Zoisite	In limestone (boulder)	Hugh Miller Inlet, Glacier Bay.

NEOZOIC INVERTEBRATE FOSSILS

NEOZOIC INVERTEBRATE FOSSILS

A REPORT ON COLLECTIONS MADE BY THE EXPEDITION

BY WILLIAM HEALEY DALL

I. EOCENE FOSSILS FROM ALASKA PENINSULA

THE Tertiary and post-Tertiary invertebrate fossils collected during the expedition and which were confided to me for examination and report, were obtained in three different regions.

Beginning with the older formations, the first region comprises an area situated on the northwest shore of Stepof or Stepovak[1] Bay on the southern side of Alaska Peninsula in west longitude about 160°. Here are a couple of small bays or coves, one of which, named after Admiral Chichagoff of the Russian navy, is called Chichagof[2] Cove and is separated by a pair of projecting

[1] The name on the charts, Stepovak, is a corruption of *Stepovakko*, which is the genitive form of the masculine proper name *Stepoff*, probably one of the persons connected with the surveys of this region carried on by the Russian American Company, 1840–50. In English the name would have been Stepoff's or Stepoff Bay.

[2] This name is sometimes pronounced by the natives 'Chicagoff' which is merely an erroneous rendering of Chichagoff.

points of land from another cove, which in this report will be referred to as West Cove, it having no local name so far as recorded by the charts.

Stepovak Bay lies north of the group known as the Shumagin Islands and southeast of Port Moller, a large bay on the north shore of the peninsula, connected with Bering Sea. A portage from the head of West Cove can be made to the shore of Port Moller, with a length of about four miles.

At the head of Chichagof Cove a gravel beach and meadow nearly cut off from the sea a large tidal lagoon, beyond which a stretch of meadow extends to the foot of the hills, one of which nearly north of the lagoon has been named by Dr. Palache Chichagof Peak. It rises to a height of some 3000 feet. The hills rise abruptly from the meadow. A more detailed description and sketch map are supplied by Dr. Palache in his notes on the geology and petrography of the locality, elsewhere in this volume.

The rocks in this vicinity so far as observed belong to the Eocene, their age being determined by the fossils herein discussed. They comprise breccias, sandstones and shales, more or less fossiliferous, though the fossils exist chiefly in the form of casts and are often distorted by shearing movements of the matrix, due to the volcanic disturbances to which the region is known to have been subjected.

The Mesozoic beds which presumably underlie these Eocene sediments crop out on the shores of Port Moller immediately to the northwest, and there, in 1874, the writer collected a number of fossils which were described by Dr. C. A. White in 1884.[1] These comprise species of *Belemnites*, *Cyprina* and *Aucella*.

On the peninsula which separates the head of Port Moller from Herendeen Bay immediately to the westward,

[1] Bull. U. S. Geol. Survey, No. 4, pp. 10–15.

there is a considerable mass of coal-bearing strata belonging to the Kenai Series of Oligocene sediments, which logically should succeed the Eocene Stepovak Series of Chichagof Cove and vicinity, though their contact has not yet been observed. To the southward, on the northern end of Unga Island of the Shumagin group, these same Kenai beds are exposed and contain not only coal but an important series of leaf beds, from which their age has been determined. A tolerably full description of the stratigraphy of the Unga locality has been published by the writer[1] from observations made in 1865, 1872 and on various occasions since. A list of the plant remains, prepared by Dr. Knowlton,[2] has also been printed.

Immediately above the beds of the Kenai Series in the Unga section appear, as the product of apparently continuous sedimentation, a thinner series of beds of Miocene age containing marine invertebrate fossils. This Miocene deposit, much broken up by volcanic dikes and intrusions of lava, extends to the eastward, being found in various localities along the north shore of Popof Island immediately eastward of Unga, where the writer obtained fossils in 1874, and where Mr. Kincaid of the Harriman party also collected a number of specimens, to be discussed later.

The only representative of the Eocene epoch known in Alaska previous to the date of the Harriman Expedition was the Kenai Series, which had been referred by Heer to the Miocene and by others to the Eocene, but which has of recent years been recognized as Oligocene by the present writer and others.[3]

The discovery of unmistakable typical Eocene strata in Alaska, therefore, is of prime importance, as filling a

[1] Correlation Papers. Neocene. Bull. U. S. Geol. Survey, No. 84, 1892; pp. 240–242. See also: Report on Coal and Lignite of Alaska by William Healey Dall, 17th Ann. Rep. U. S. Geol. Survey, 1895–6, Part 1, 1896, pp. 807–811.

[2] Report on Coal and Lignite of Alaska (supra), Appendix 1, pp. 876–897.

[3] Report on Coal and Lignite of Alaska (supra), pp. 838–9.

gap in the geological column heretofore inexplicably vacant. Stratigraphically it is the most important discovery in geology made by the Harriman party, and Dr. Palache is to be heartily congratulated on his success in obtaining material by the determination of which this discovery is made certain.

Dr. Palache's party camped on the eastern side of Chichagof Cove near the outlet of the lagoon, and the localities where fossils were obtained were noted by him as follows, the number preceding each note being that assigned the locality in our record book.[1]

3373. Beds near the camp on the eastern side of Chichagof Cove, belonging to what Dr. Palache has designated on his sketch chart as the 'upper beds' of the Stepovak series. (See pages 75 and 77.)

3374. From the west headland of Chichagof Cove, beds similar to those of 3373.

3375. From the east side of West Cove, the beds belonging to the upper series.

3376. From the hill above the camp, the same horizon as at the camp, but about a mile along the strike.

3377. From slope of Chichagof Peak, beds belonging to the 'lower' series of Dr. Palache, near a dike. (See page 74.)

3378. From the breccia beds of the same lower series as 3377, on the slope of Chichagof Peak.

That some difference in age exists between the beds of the lower and upper series is obvious, but that this difference involves a faunal difference is not so certain since several of the species found in the lower beds were also collected from the upper beds, and the total number from the lower beds is too small to admit of any valuable comparison being made. If any faunal difference exists it is

[1] The collections, including the type specimens, are in the U. S. National Museum, at Washington, D. C.

probably not greater than that between the Chickasawan and Claibornian horizons in the standard Alabama column, to which we are accustomed to refer our correlations of the Eocene horizons of the east American Tertiaries.

Five species were obtained from the lower beds, one being the *Venericardia planicosta* Lamarck, the well known 'finger post of the Eocene' which, with two others of the five, was also obtained from the upper beds.

Owing to the poor condition of the fossils and the frequent deformation of the casts by shearing, a number of the species are here determined only generically, it being thought best to defer naming specifically material which might lead to confusion when better specimens turn up at some future time.

As is natural, a large proportion of the species appear to be new, and of these eleven seem to be in condition which renders it safe to describe and name them.

An enumeration of the fauna obtained by Dr. Palache now follows.

LIST OF THE INVERTEBRATE FOSSILS

PORIFERA

Cliona alaskana Dall.

Locality. — Upper beds, 3373.

The numerous oysters which occur in the tough greenish-black shales of these beds are frequently dotted with minute circular holes closed by matrix. On breaking them open the interior of the shell is seen to be excavated by numerous inosculating galleries, sometimes merging into irregular cavities with rugosely curved walls. These are the work of the sponge *Cliona* which, in its younger stages, forms these burrows in the shell, the water and the food it bears finding access to the sponge through the small circular orifices above mentioned. In the absence of the sponge itself or its spicules it is of course impracticable to enumerate distinctive specific characters, but as the borings are quite recognizable and the species was doubtless distinct from the recent *Cliona sulfurea*, it may for convenience of reference take the name *Cliona alaskana*.

MOLLUSCA

PELECYPODA

Leda sp.

Locality. — Upper beds, 3373.

A species of *Leda* is represented by a single crushed valve 23 mm. long and 12 mm. high, rather convex, with nearly central beaks, rounded in front and somewhat recurved behind. The surface appears to have been concentrically somewhat irregularly, finely striated. The hinge is inaccessible, and the form recalls *Leda acala* of the Woods Bluff, Alabama, Eocene, but it is wider behind and more recurved.

Yoldia palachei sp. nov.

Pl. IX, fig. 4.

Locality. — Upper beds, 3373.

Shell large, plump, smooth, rounded in front and behind, the beaks somewhat nearer the anterior end; anterior dorsal slope convexly arcuate, base evenly arcuate, posterior end slightly recurved, posterior dorsal slope slightly concave; hinge teeth small, about two to a millimeter; hinge largely inaccessible. Length of shell 29, height 15, diameter about 8 mm.

The form of this species recalls *Y. montereyensis* Dall of the recent fauna, but it is more slender, especially behind, and proportionately more elongated. It is named in honor of Dr. Charles Palache, of Harvard University, one of the geologists of the Harriman party.

Yoldia emersonii sp. nov.

Pl. IX, fig. 8.

Shell of moderate size, the beaks at the anterior third, bluntly rounded in front, produced, compressed, rounded and recurved behind; the base evenly arcuate, the anterior and middle parts of the shell moderately convex; the teeth small, the line of teeth rather short; the posterior dorsal slope somewhat concave. Length 18.5, height 11, diameter about 5 mm.

Locality. — Upper beds, 3373.

The surface appears to have been smooth. The species is named in honor of Prof. B. K. Emerson, of Amherst College, one of the geologists of the Harriman party.

Yoldia breweri sp. nov.

Pl. IX, fig. 5.

Shell rather large, short, moderately convex, compressed behind, the posterior end acutely rostrate, short and abruptly recurved; base roundly arcuate; anterior dorsal slope convex; posterior slope deeply concavely excavated; hinge mostly hidden, teeth small, about three to a millimeter; surface smooth. Length about 25, height 18, length from the beaks to the posterior end 13.5, diameter about 8 mm.

Locality.—Upper beds, 3373.

Although the impression of the valve is incomplete in front, the form is so remarkable that it seems desirable to apply a name to this species, which has an outline somewhat like Gabb's *Meekia navis*. It is named in honor of Prof. W. H. Brewer, of Yale University, a member of the Harriman Expedition and formerly of the Geological Survey of California.

Nucula (Acila) decisa Conrad.

Pl. IX, fig. 2.

Nucula decisa CONRAD, Pacific R. R. Reps., vol. V, p. 322, pl. 3, fig. 19, 1856.—DALL, Trans. Wagner Inst., III, p. 573, pl. XL, figs. 1, 3, 1898.
Nucula divaricata CONRAD, 1848, not of Valenciennes, 1839.
Nucula conradi MEEK, Checkl. Mio. fos., p. 5, 1864.
Nucula castrensis GABB, Pal. Cal., II, p. 102, 1868; not of Hinds, Voy. Sulph., Zoöl., p. 61, 1848.

This species, characteristic of the Eocene of Oregon, is rather common in the upper beds at Chichagof Cove, but the specimens are often greatly distorted by shearing. The one figured, though apparently intact, has been elongated to nearly twice its normal length, the form being normally ovate trigonal. The surface is marked with fine divaricate sculpture; the teeth are strong and sharply folded.

Glycimeris sp.

Locality.—Upper beds, 3373.

Shell, when unchanged by pressure, nearly orbicular, plump, concentrically striated, the inner basal margin entire. Length 21, height 22, diameter about 8 mm. The shell can be distinguished from distorted specimens of *Acila decisa*, which sometimes resemble it, by its smooth unfolded teeth.

Ostrea sp.

Locality.—Upper beds, 3374.

A crushed specimen of *Ostrea* resembling *O. thirsæ* Gabb, from the Eocene of Texas was obtained at this locality.

Ostrea sp.

Localities.—Upper beds, 3373; lower beds, 3377.

A large species in imperfect condition but resembling closely *O. idriaensis* Gabb, from the Tejon Eocene of California. Specimens reach a length of 80, and a breadth of 55 mm., and are frequently perforated by the *Cliona alaskana*.

Pecten (Chlamys) sp.

Locality.—Upper beds, 3373.

Fragments of the upper valve of a *Pecten* of the type of *P. islandicus* Müller having nineteen ribs on the disk and six on the posterior auricle, with traces of a fine reticulate surface sculpture, were obtained by Dr. Palache. The height of the valve would be about 40 mm. and the proportions about those of *P. islandicus*.

Modiolus harrimani sp. nov.

Pl. IX, fig. 7.

Localities.—Upper beds, 3373; lower beds, 3378, very abundant but crushed.

Shell small, short, broad, with nearly terminal beaks; anterior end narrow, rounded, blunt; posterior end broad, compressed, subtruncate; base nearly straight, with the valve above it and below the median convexity somewhat impressed. Length 19, maximum width 12.5, diameter about 6 mm.

This curiously wedge-shaped little *Modiolus* is concentrically striated. It is very abundant but always distorted in the lower beds; a single valve in normal condition was found in the upper beds.

Modiolus sp.

Locality.—Lower beds, 3377.

A fragment of a large rounded quadrate species recalling the recent *M. vulgaris* was collected. It is rather strongly concentrically sculptured.

Modiolus alaskanus sp. nov.

Pl. X, fig. 3.

Locality.—Upper beds, 3373.

Shell small, rounded quadrate, finely concentrically striated, moderately convex; anterior end with the beaks adjacent, rounded; base nearly straight; posterior end wider, rounded, obliquely subtruncate; ventral third with the usual constriction. Length 17, maximum width 9, diameter about 4 mm.

Modiolus (Botula?) sp.

Locality.—Upper beds, 3374.

A small calcareous nodule from the shale contains part of the imprint of a small, stocky, solid, strongly concentrically striated species recalling, as far as its characters were evident, some of the species of *Botula*. It has a length of about 10, and a height of 4 or 5 mm.

Venericardia planicosta Lamarck.

Venericardia planicosta Lamarck, Ann. du Museum, vii, p. 55; ix, pl. 31, fig. 10, 1805.

Localities.—Upper beds, 3373; lower beds, 3377.

Unmistakable fragments of this most characteristic Eocene type were found in both upper and lower beds. They appear to be of the ordinary form rather than the variety with obsolete sculpture called *hornii* by Gabb. One imprint preserves the impression of the hinge teeth.

Phacoides? sp.

Locality.—Upper beds, 3373.

An imperfect imprint of a shell which may be a *Phacoides*. It is rounded with sculpture, recalling that of *P. jamaicensis* Lam., and has a height of about 15 mm.

Macrocallista (Chionella?) gilberti sp. nov.

Pl. ix, fig. 10.

Shell moderately convex, ovate trigonal, nearly equilateral, smooth; the beaks rather full and elevated, anterior end rounded, base arcuate, posterior end somewhat longer, roundly pointed; muscular impressions obscure; pallial sinus short, angular, free from the pallial line below. Length 42, height 30, diameter about 12 mm.

Locality.—Upper beds, 3373.

The hinge is inaccessible but this shell has the aspect of a *Chionella*. It is named in honor of Mr. G. K. Gilbert, one of the geologists of the Harriman party.

Macrocallista (Chionella) sp.

Locality.—Upper beds, 3375.

This species is shorter and higher than *M. gilberti* and more nearly orbicular in outline. It is about 33 mm. long, 28 mm. high, and 20 mm. in diameter. The beaks are notably small and elevated.

Tellina sp.

Locality.—Upper beds, 3373.

This species closely resembles in its outline *Yoldia palachei*, though

it is less arcuate and subtruncate terminally behind; but it shows the hinge of *Tellina* with well developed anterior and posterior lateral laminæ. The surface appears to have been nearly smooth. The shell is more convex than one expects a *Tellina* to be, recalling in this respect the species of *Psammacoma* which have no lateral teeth. It has a length of 24, a breadth of 12, and a diameter of about 5 mm.

Spisula callistæformis sp. nov.

Pl. IX, fig. 9.

Shell elongate, recalling *Macrocallista* in outline, the anterior end slightly shorter, attenuated and rounded in front, arcuate below, wider and rounded behind with an obscure radial ridge near the dorsal slope; disk slightly flattened, concentrically striated, the beaks pointed and moderately elevated. Length 50, height 28, diameter about 16 mm.

Locality.—Upper beds, 3373.

This species is rather abundant and uniform. The pallial sinus is deep and free from the pallial line for most of its length below. The hinge as far as observable is that of *Spisula* or *Cymbophora.*

Spisula sp.

Localities.—Upper beds, 3375 and 3376.

This species, though represented by very inferior specimens, is obviously more convex, more trigonal, and had a heavier shell than *S. callistæformis.* The pallial sinus in one specimen is decidedly shorter and more angular than in that species.

Mesodesma alaskensis sp. nov.

Pl. IX, fig. 1.

Shell solid, heavy, nearly smooth with a few feeble concentric lines, very inequilateral; the beaks low, blunt; the anterior end long, rounded behind, with a nearly straight base and a short bluntly truncate posterior end. Length 29, height 20, diameter about 7 mm. The beaks are at about the posterior third of the length of the valve.

Locality.—Upper beds, 3373, 3374, 3375.

This species is abundant but usually more or less distorted by shearing. It recalls *M. singleyi* Harris from the lower Claibornian of Lee County, Texas.

GASTROPODA

Drillia? sp.

Locality.—Upper beds, 3373.

A much distorted, very imperfect gastropod which may possibly be a *Drillia* is among the specimens collected.

Clavellithes? sp.

Locality.—Upper beds, 3373.

An imperfect gastropod fossil which has the aspect of a *Clavellithes* is among the specimens collected.

Chrysodomus sp.

Locality.—Upper beds, 3375.

A specimen which appears to be the internal cast of a *Chrysodomus* was collected. The upper part of the spire and most of the canal are missing. On the upper of the two whorls present there appears to have been a single strong carina, somewhat wavy or nodulous, and a little above the middle of the whorl, forming a sloping but very marked shoulder; on the second or body whorl there are three feebler spiral ridges below the shoulder, and about equidistant. The canal is recurved and was apparently short. The height of the body whorl, from the beginning of the canal to the suture, is 27, and the diameter 35 mm.

This shell is of the type of *Chrysodomus liratus* Martyn, and offers an example of the persistence of a particular type in a given region which is very interesting.

Rimella? ? sp.

Locality.—Upper beds, 3373.

A fragment of a gastropod which recalls the surface of *Rimella simplex* Gabb, from the Californian Eocene, is among the material collected, but the generic determination is far from being certain.

Cassis sp.

Locality.—Lower beds, 3377.

The canal and back of the body whorl of a *Cassis* somewhat resembling the *C. shubutensis* from the Eocene of Shubuta, Miss., are visible in a piece of shale from the locality above mentioned. The specimen is more elongated than *C. shubutensis*, is covered with finer spiral sculpture, and exhibits five rather feeble nodulations on the shoulder of the whorl; presumably the whole shell had ten or twelve of these. The length of the portion preserved is 17, and the diameter 11.5 mm.

Cerithium? sp.

Locality.—Upper beds, 3373.

Two fragments of what is probably a Cerithioid shell are preserved. They have rounded whorls with deep sutures, the upper whorls with feeble sculpture, the basal whorl with six or more strong spiral ribs. There is no evidence of axial sculpture of any strength. The shell

increases in diameter too rapidly to be a *Turritella*, and is unlike any *Scala* I know in the Eocene. It had a length of over 80 mm., in seven whorls, and the last whorl had a diameter of over 30 mm. A surmise seems warranted that the shell belongs to the group of large Cerites which are known to occur both in the Alabama and the Parisian Eocene.

Crepidula precursor sp. nov.

Pl. IX, fig. 3.

Shell small, smooth, rather depressed, rounded ovate; the beak small, prominent, strongly incurved. Length 13, breadth 10, height about 3.5 mm.

Locality.—Upper beds, 3374.

The shell is flatter and the beak less spiral than in *C. pileum* Gabb of the Tejon Eocene of California, but the characters of the internal plate are inaccessible.

? Ampullina crassatina Lamarck.

Ampullaria crassatina LAMARCK, Ann. du Museum, V, p. 33, 1805; VIII, pl. LXI, figs. 8a–b.

Natica mississippiensis CONRAD, Proc. Acad. Nat. Sci. Phila., III, p. 283, 1847.

Locality.—Upper beds, 3373.

A cast of a Naticoid shell having a very strong resemblance to the Eocene species above referred to, is in the collection. It is not sufficiently perfect to be positively identified but is probably this species.

Natica sp.

Locality.—Upper beds, 3375.

Fragments of a Naticoid shell in some respects recalling *N. semilunata* Lea, of the Claibornian, were collected as above.

Margarites peninsularis sp. nov.

Pl. IX, fig. 6.

Shell of moderate size, turbinate, with about five rounded whorls; nuclear whorls obliquely transversely striated by the lines of growth, strongly mesially, spirally keeled; keel entire and continuous but less conspicuous and relatively feebler on the later whorls; sutures deep, not channelled, base rounded; umbilicus (not accessible); aperture subcircular, with a thin margin. Height of the shell about 12, diameter about 12 mm.

Localities.—Upper beds, 3373, 3374, 3376.

The specimens of this elegant shell are either crushed or so much

embedded in a very tough matrix that the characters are not all determinable, but it should be recognizable from those above enumerated.

It recalls the recent species of the same region, like *M. pupilla* Gould, though less elaborately sculptured.

Dentalium sp.

Locality.—Upper beds, 3374.

A large species of *Dentalium* occurs in these beds, rounded at the upper part with transverse feeble striation, the more slender portion behind smooth and obscurely six-sided, an appearance which may be due to pressure. It reaches a length of at least 70 mm., and a diameter near the aperture of 5 mm.

The total Eocene fauna of the Stepovak Series above described thus comprises at least thirty-four species, and it is probable that by continued and systematic collecting a very much larger number might be obtained.

II. MIOCENE FOSSILS FROM THE SHUMAGIN ISLANDS

In 1865, 1872, and other later dates the writer collected specimens from the Crepidula bed over the leaf beds in the northwestern peninsula of Unga Island, Shumagins. Collections were also made in 1874 on the north shore of Popof Island, between Popof Strait and Pirate Cove. During the stay of the Harriman Expedition at Humboldt Harbor, Sand Point, Popof Island, Mr. Trevor Kincaid also collected from the Popof Island beds. The number of species being small, I have combined them in one list. The locality numbers are as follows:[1]

2103. Coal Bluff, Unga Island, Miocene horizon above the leaf beds, collected by Dall in 1865, 1872 and 1880.

3563. Miocene stratum, same horizon as the preceding, collected by Dall in 1874 and 1880, north shore of Popof Island.

3372. Same horizon, north shore of Popof Island, col-

[1] The collections are in the U. S. National Museum, Washington, D. C.

lected by Mr. Trevor Kincaid in 1899, during the Harriman Expedition.

This horizon contains several species identical with those of the Miocene at Astoria, Oregon, and on the south shore of the Strait of de Fuca, State of Washington. It is probably of identical age. To this horizon, following Professor Condon in the *American Naturalist* in 1880, the writer in 1892 gave the name Astoria Group. It is that portion of the Pacific coast Miocene north of Cape Mendocino which conformably and immediately follows the Kenai Group of Oligocene lignite and leaf beds, and is probably itself succeeded by the series of which an excellent exposure is found at Coos Bay, Oregon, and which was named by Diller the Empire beds.

A number of species from the Unga locality, and also from the same horizon on other islands and the mainland, are described or cited by Grewingk in his classical memoir on the geognosy of northwest America.[1] Those cited from Unga are included in this list to make it as complete an account as possible of the fauna of the Miocene beds of Zakharof Bay, Unga Island, and the north shore of Popof Island.

Those from other localities, not proven to be of the same horizon, are omitted.

LIST OF SPECIES

MOLLUSCA

PELECYPODA

Glycimeris kashevarofi Grewingk.

Pectunculus kaschewarowi GREWINGK, Beitr. NW. Am., p. 279, pl. v, figs. 3a–d, 1850.

Localities. — Unga Island, the peninsula of Alaska, near Pavlof volcano, and the island of Kadiak, near Tonki Cape, Igatskoi Bay.

[1] Beitrag zur Kenntniss der orographischen und geognostischen Beschaffenheit der Nordwest Küste Amerikas, mit den anliegenden Inseln. Von Dr. C. Grewingk, St. Petersburg, Karl Kray, 1850, 8°, pp. iv, 351, and seven plates.

The name of the collector of this material being Kashevarof, I have corrected the Germanized orthography of Grewingk accordingly.

Ostrea sp.

Ostrea sp. (plicate) GREWINGK, Beitr. NW. Am., p. 289, 1850.

Localities.— Unga Island and the peninsula of Alaska near the Pavlof volcano.

Some plicated oysters were obtained as above which Grewingk regarded as specifically different from the following species, of which I have some doubt.

Ostrea tayloriana Gabb.

Ostrea longirostris LAMARCK, var., GREWINGK, Beitr. NW. Am., p. 288, 1850.

Ostrea tayloriana GABB, Pal. Cal., II, p. 34, pl. XII, figs. 60, 60a, 1866.

Localities.— Unga Island and near Pavlof volcano on the peninsula of Alaska (Grewingk). Popof Island, 3372 and 3563.

The most abundant fossil on Popof Island in this horizon is an oyster which much resembles the common species of eastern America, *Ostrea virginica* Gmelin.

This appears to be the form which Gabb named *O. tayloriana*, though the crushed and disintegrated specimens from Popof Island are in such a condition as to make the determination not absolutely certain, though highly probable.

Pecten (Chlamys) fucanus Dall.

Pecten (*Chlamys*) *fucanus* DALL, Trans. Wagner Inst., III, 704, pl. 26, fig. 7, 1898.

Localities.— Miocene of Clallam Bay, Fuca Strait, twenty-five miles eastward from Cape Flattery; Popof Island, Alaska, 3563.

Mytilus middendorffi Grewingk.

Mytilus middendorffi GREWINGK, Beitr. NW. Am., p. 287, pl. VII, figs. 3a–3c, 1850.

Localities.— Unga Island, and on Kadiak Island near Cape Tonki, Igatskoi Bay (Grewingk).

A peculiar *Mytilus* with the distal portions of the valves sculptured by two or three broad plications. It is represented in the Pliocene of Oregon by *Mytilus condoni* Dall which is somewhat similarly sculptured.

Cardium ciliatum Fabricius.

Cardium ciliatum FABRICIUS, Fauna Grönl., p. 410, 1780.—G. O. SARS, Fauna Reg. Arct. Norv., p. 46, pl. 5, figs. 4a–4b, 1878.

Locality.— Popof Island, 3563.

Cardium decoratum Grewingk.

Cardium decoratum GREWINGK, Beitr. NW. Am., p. 274, pl. IV, figs. 3a–3g, 1850.

Localities.—Miocene of Unga Island; Kadiak Island at Ugak or Igatskoi Bay, Tonki Cape; and Pavlof Bay, Alaska Peninsula; Pliocene of St. Paul Island, Bering Sea (Grewingk); Pleistocene of Douglas Island, Alaska (Dall), and Vancouver Island, British Columbia (Newcombe).

Serripes gronlandicus Gmelin.

Cardium grönlandium (CHEMNITZ) GREWINGK, Beitr. NW. Am., p. 277, pl. IV, figs. 4a–4b, 1850.

Localities.—Miocene of Unga Island; Kadiak Island (Grewingk); Pleistocene of St. Paul Island, Bering Sea; recent in the Arctic and boreal seas.

Papyridea harrimani sp. nov.

Pl. X, fig. 5.

Shell inflated, large, ovate, gaping behind, the anterior end slightly shorter; sculpture of more than thirty-five slender radial ribs, distributed toward the middle of the disk, flattish, with low, transverse nodulations distributed in a generally concentric manner, the interspaces of the ribs finely transversely striated; at the anterior end the ribs become feebler and more slender, being hardly perceptible on the cast; near the posterior end they appear to cease abruptly, leaving a posterior area over which the sculpture is obsolete; valves rounded in front, arcuate below, moderately inflated; beaks low. Length of shell about 45, height 38, diameter about 25 mm.

Locality.—Popof Island, 3372.

This fine large species has no analogue in the recent fauna. Though an internal cast, there are some small bits of the shell adhering which give data for the external sculpture. It is named in honor of Mr. E. H. Harriman, patron of the Expedition.

Diplodonta sp.

Locality.—Popof Island, 3372.

Casts of a rounded *Diplodonta*, 25 mm. long and 24 mm. high, with a diameter of about 20 mm., were obtained. They appear to have had a thin concentrically striated shell, with low beaks, smooth margins, and the muscular scars of the typical *Diplodonta*. This may be identical with the *Sphærella oregona* Conrad mentioned in the Smithsonian checklist of Eocene fossils, p. 6, 1866, but of which I have so far been unable to find a published description.

Saxidomus popofianus sp. nov.

Pl. x, fig. 4.

Shell rather evenly ovate, inequilateral, with low beaks nearer the anterior end; dorsal slopes slightly descending, the beaks near the anterior third of the shell; ends evenly rounded, base moderately arcuate; internal margins smooth; muscular scars deeply impressed; pallial line rather distant from the ventral edges of the valves, with a small, short, ascending subangular sinus free from the pallial line below; external surface rather rudely and irregularly concentrically sculptured. Length of internal cast 50, height 37, diameter 38.5 mm.

Locality.—Popof Island, 3372.

This is one of the most abundant species of the Miocene beds of Popof Island.

? **Callocardia (Pitaria) kincaidii** sp. nov.

Pl. x, fig. 1.

Shell elongate-ovate, plump, inequilateral, with large and prominent beaks three-tenths of the length behind the anterior end; anterior dorsal slope short, excavated; posterior slope longer and nearly straight; pointed rounded at both ends, base arcuate; pallial line with a short, wide, rounded, ascending, free sinus; exterior concentrically striated. Length 50, height 35, diameter 21 mm.

Locality.—Popof Island, 3372.

This species is referred to the above group on account of its general aspect, as the hinge is inaccessible. It is quite common in the beds referred to. It is named in honor of Mr. Trevor Kincaid, of Seattle, who collected it with other fossils from Popof Island.

Dosinia? alaskana sp. nov.

Pl. x, fig. 7.

Shell suborbicular, rather convex, with very high prominent beaks nearer the anterior end; anterior slope short, deeply excavated; posterior slope convexly arcuate; base arcuate; pallial sinus short, angular, free from the pallial line below; internal margins simple. Length 55, height 53, diameter 22 mm.

Locality.—Popof Island, 3372.

This species has the hinge obscured, but is probably a *Dosinia*. The surface is concentrically sharply striated.

Protothaca grewingkii sp. nov.

Venerupis petitii var. GREWINGK, Beitrag, NW. Am., p. 278, pl. v, figs. 2a–2e, 1850; not of Deshayes.

Localities.—Unga Island and near the Pavlof volcano on the Peninsula of Alaska (Grewingk).

This shell belonging to the group of *Protothaca staminea* Conrad, formerly called *Tapes*, is obviously distinct from that species (which was later named *V. petitii* by Deshayes) by reason of its coarser radial sculpture and other characters evident on comparison.

Protothaca? sp.

Locality.—Popof Island, 3372.

A form evidently belonging to the *Veneridæ* and perhaps to *Protothaca* but without traces of radiating sculpture near the beaks, where alone the shell is partly preserved.

It has a free, deep, ample pallial sinus subangular in front; has the beaks in the anterior third, smooth interior margins, rather bluntly rounded ends and arcuate base. The general form is rounded-quadrate. It is 45 mm. long, 39 mm. high, and 19 mm. in diameter, the measurements being taken from the internal cast.

Macoma (edentula Broderip and Sowerby, var.) **grewingkii** Dall.

Tellina edentula BROD. & SBY., Zool. Voy. Blossom, p. 134, pl. 41, fig. 5, and pl. 44, fig. 7, 1839; Zool. Journ. IV, p. 363.—GREWINGK, Beitrag NW. Am. p. 284, pl. VII, figs. 1a–1c, 1850.

Locality.—Unga Island (Grewingk).

This shell has much the form of the recent species to which Grewingk referred it as a variety, but is probably distinct, as the form of the pallial sinus is not the same. I have not been able to examine specimens.

? Tellina (Peronidia) lutea Gray.

Tellina lutea GRAY, Index Test. Suppl., pl. 1, fig. 3c, 1828.—GREWINGK, Beitrag NW. Am., p. 286, 1850.—DALL, Proc. U. S. Nat. Mus., XXIII, p. 322, pl. IV, figs. 15, 16, 1900.

Locality.—Unga Island (Grewingk).

I have not seen specimens, but when they are obtained it may well happen that they will prove distinct from the recent *T. lutea.*

Solen sp.

Locality.—Popof Island, 3372.

A fragment of a large *Solen*, 22 mm. wide at its posterior end, was obtained by Mr. Kincaid.

Mya crassa Grewingk.

Mya crassa GREWINGK, Beitrag NW. Am., p. 282, pl. VI, figs. 2a–2d, 1850.

Localities.—Unga Island; and near the Pavlof volcano, on the Peninsula of Alaska (Grewingk).

A large, heavy, subtriangular form, possibly a mutation of the following species.

Mya arenaria (L.?) Grewingk.

Mya arenaria GREWINGK, Beitrag NW. Am., p. 283, pl. VI, figs. 3a–3c, 1850.

Locality.—Unga Island (Grewingk).

The true *Mya arenaria* seems unknown from the Pacific coast, except as introduced with seed oysters in the recent fauna. The form analogous to it, but which is never exactly the same, has often been cited as *arenaria* and also under a name *Mya præcisa*, which Gould gave to a mutation of *Mya truncata* L., but it is probable that the name *crassa* bestowed as above by Grewingk will have to be retained for it, as in collections of the recent form I have found both the typical *M. crassa* and that which Grewingk called *arenaria* to be united by intermediate mutations.

Mya truncata Linné.

Mya truncata LINNÉ, Syst. Nat., Ed. X, p. 670, 1758.—LYELL, Trans. Geol. Soc. Lond., VI, p. 137, pl. XVII, figs. 5–6, 1841.—GREWINGK, Beitrag NW. Am., p. 283, 1850.

Localities.—Unga Island, Kadiak Island, and the vicinity of the Pavlof volcano, on the peninsula of Alaska (Grewingk). Also in the Pliocene, Pleistocene and recent faunas abundantly.

Saxicava ungana Grewingk.

Saxicava ungana GREWINGK, Beitrag NW. Am., p. 281, pl. VI, figs. 1a–1c, 1850.

Locality.—Unga Island (Grewingk).

It is somewhat doubtful if this is distinct from the *S. arctica* L., but not having seen specimens I retain the name for the present.

Teredo ? sp.

Locality.—Popof Island, 3372.

Casts of large borings resembling those of *Teredo* and having an average diameter of 19 mm., were obtained. They appear to have had originally a circular section but are somewhat distorted by pressure.

GASTROPODA

Chrysodomus sp.

Tritonium sp. GREWINGK, Beitrag NW. Am., p. 290, 1850.

Locality.—Popof Island, 3372; Makushin Bay, Unalaska (Grewingk).

Very poor casts of a species resembling *C. fornicatus* Gray were obtained.

Chrysodomus sp.

Locality.—Popof Island, 3563.

A slender species with strong spiral ridges resembling *C. liratus* Martyn was obtained, in fragmentary specimens.

Tritonofusus sp.

Locality.—Popof Island, 3372, 3563.

Fragments of a species recalling *T. stimpsoni* Mörch were obtained.

Volutharpa ? sp.

Locality.—Popof Island, 3372.

A poor cast of what may be a *Volutharpa* or a short stout *Buccinum* was obtained.

Buccinum ? sp.

Locality.—Popof Island, 3372.

A specimen containing in a very tough matrix the five upper whorls of what may be a small species of *Buccinum* was collected. The nuclear whorls are smooth, the later ones sharply evenly spirally grooved with about three channels to the millimeter, and, on the shoulder, a succession of short low nodulous waves axially directed. The suture is appressed but distinct. The height of the specimen visible is about 8 mm. and the maximum diameter 7 mm.

Trochita alaskana sp. nov.

Pl. x, figs. 2, 6.

Shell of moderate size, and about four convex whorls separated by a well-defined suture, beneath which they are sometimes a little constricted, but always more or less convex, with the surface obliquely and rather irregularly striated; individuals vary in form from quite elevated to moderately conical; the periphery of the whorl is at the same time the periphery of the base, there being no overhanging margin or keel as in *Calyptræa;* base smooth, concave, the umbilical region imperforate or covered by the reflexed columellar margin;

basal margin of the aperture arcuate, not advancing as far as the upper margin, which is oblique and anteriorly extended at the suture. Height 13 to 20, diameter of base about 25 mm.

Localities. — Popof Island, 3372, 3563, also in the Crepidula bed at Unga Island.

This is one of the most abundant species among the shells from Popof Island, and like most limpets quite variable in form. It can be distinguished from its nearest congener, *T. simplex* Gabb, from the Miocene of California, by the convex whorls, as the slope from the apex of *T. simplex* to the periphery of the base is nearly a right line.

Crepidula ungana sp. nov.

Pl. x, figs. 8, 9.

Shell about the size of *C. fornicata* Lam., ovate, vertically somewhat compressed, having about a whorl and a half; surface rudely and irregularly concentrically sculptured by the incremental lines, without spines or spiral sculpture; apex small, narrow and recurved to half the height of the shell above the base, its nuclear part pointing nearly vertically; aperture rather narrow, wider in front, the columellar margin somewhat reflexed below the spire. Maximum length of shell 38, width 25, height 18 mm.

Locality. — Miocene bed at Coal Bluff, Unga Island, in very great abundance, giving the name of Crepidula bed to this particular stratum.

This species was long identified with *Crepidula prærupta* Conrad, from the Miocene of Astoria, very badly figured in the Geology of the Wilkes Exploring Expedition (pl. 19, figs. 9, 10, 1849), an internal cast of which was later named *Crypta rostralis* by Conrad.

A comparison however with Conrad's type shows that the two species are distinct, the narrow recurved apex of the Unga shell being a specially strong character. The Astoria species is also more capacious and convex.

Neverita sp.

Locality. — Popof Island, 3372.

Very imperfect casts of a species of *Neverita* are not uncommon in the material obtained. The form may be new but is too imperfectly represented for description.

ANNULATA

Annelid tube

Locality. — Popof Island, 3372.

A tube, presumably that of an annelid worm, is visible on the surface of one of the bivalves from Popof Island.

SUMMARY

The above list shows as the known fauna of the Miocene of Unga and Popof Islands, Alaska, thirty-one species of invertebrates, which more thorough exploration would doubtless much increase. The list shows:

Species of	No.	New.
Pelecypoda	22	6
Gastropoda	8	2
Annelida	1	

The present list adds about sixteen species to the number of those known to exist in this horizon in Alaska.

III. PLEISTOCENE FOSSILS FROM DOUGLAS ISLAND

The space between Douglas Island, the mainland and a sand-bar extending across the channel from the island northward to the mainland, constitutes Juneau Harbor, Alaska, and its immediate approaches. The shores of the island rise steeply from the water and are covered with sand, mud and gravel to a considerable height. This material resembles that of the 'Leda clays' of the St. Lawrence valley or the marine Pleistocene deposits of the Maine coast. The geological features of this vicinity have been discussed by Mr. Gilbert in volume III of this series. It is only necessary here to state that on climbing the slope alongside of a trench which had been dug to convey water pipes from the upper portion of the island down the slope to the town of Douglas, I discovered that for a certain distance these deposits contained marine fossil invertebrates. These ceased abruptly at a height determined by pocket aneroid as 200 feet above the sea-level at high water. It was evident that at the time of the deposition of this boulder clay and gravel the level of the

land relatively to the sea must have been about 200 feet lower than it is at present.

Having only a few hours at my disposal, I confined my attention to collecting a series of the species represented. A list of these is appended.

LIST OF SPECIES

CORALLIA

Astrangia sp. nov.

ANNULATA

Spirorbis sp. Also recent.
Serpula sp. Also recent.

CRUSTACEA

Balanus sp. Also recent.

MOLLUSCA

Leda fossa Baird. Also recent.
Pecten hericeus Gould var. *navarchus* Dall. Also recent.
Astarte borealis Schumacher. Also recent.
Venericardia stearnsii Dall. Also recent.
Cardium ciliatum Fabricius. Also recent.
Cardium decoratum Grewingk. Also found in the boulder clays of Vancouver Island.
Serripes gronlandicus Gmelin. Also recent.
Macoma balthica Linné var. *inconspicua* Broderip and Sowerby. Also recent.
Macoma calcarea Gmelin. Also recent.
Mya truncata Linné. Also recent.
Panomya ampla Dall. Also recent.
Saxicava arctica Linné. Also recent.
Chrysodomus liratus Martyn. Also recent.
Lunatia pallida Broderip and Sowerby. Also recent.

BRACHIOPODA

Hemithyris psittacea Gmelin. Also recent.

This list is short, containing only nineteen species, of which two are not known in the recent state. But we can infer from it, that, while the fauna as a whole is still

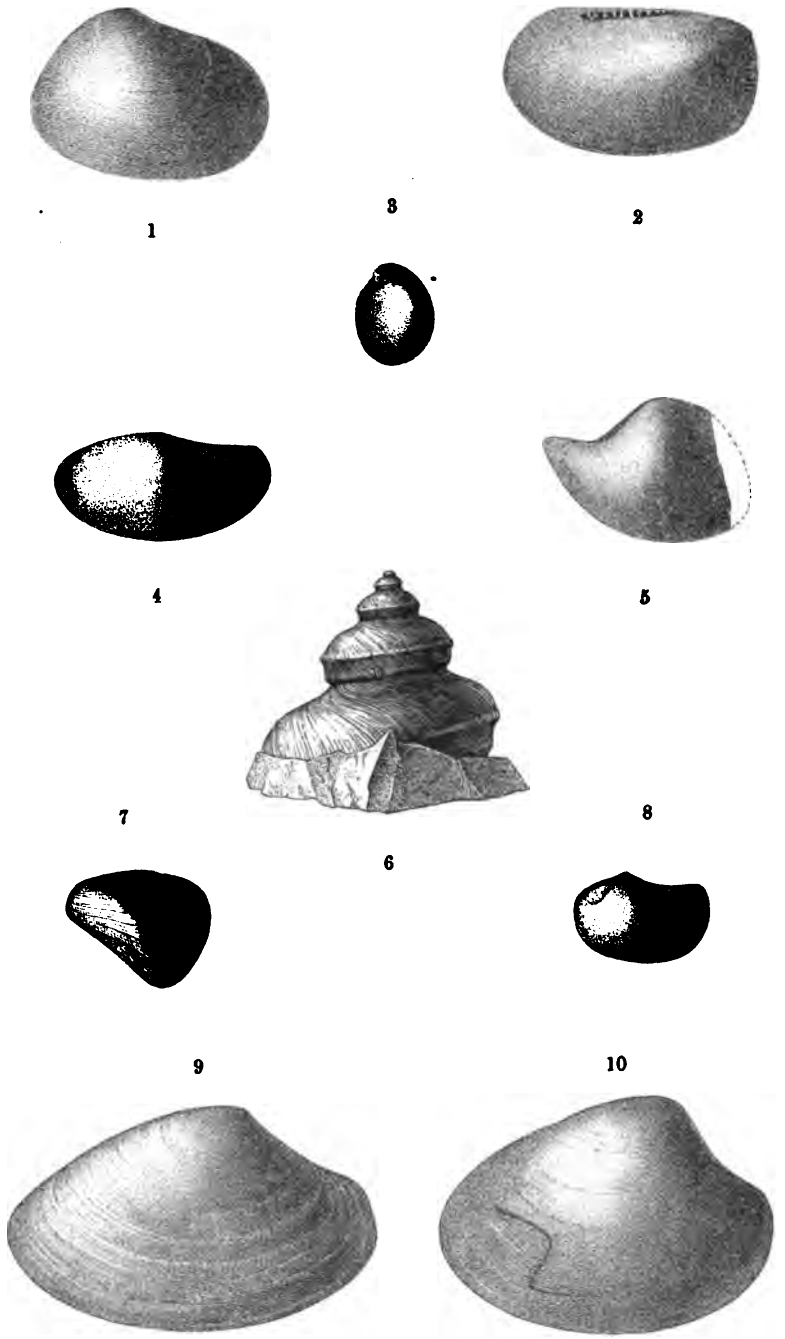
represented on the Alaskan coast and many of the species might be dredged to-day in the channel near Douglas Island, still there are three or four which are not now found, except considerably further north; and the conditions under which this fauna existed were doubtless measurably colder than at present in the same locality.

EXPLANATION OF PLATE IX

EOCENE FOSSILS

FIG. 1. *Mesodesma alaskensis* Dall; length 29.0 mm.; p. 108.

2. *Nucula* (*Acila*) *decisa* Conrad, internal cast, elongated by pressure; length 30.0 mm.; p. 105.
3. *Crepidula precursor* Dall; length 13.0 mm.; p. 110.
4. *Yoldia palachei* Dall; length 29.0 mm.; p. 104.
5. *Yoldia breweri* Dall; height 18.0 mm.; p. 105.
6. *Margarites peninsularis* Dall; height 12.0 mm.; the basal part of this specimen is imbedded in a very hard matrix; p. 110.
7. *Modiolus harrimani* Dall; length 19.0 mm.; p. 106.
8. *Yoldia emersonii* Dall; length 18.5 mm.; p. 104.
9. *Spisula callistæformis* Dall; length 50.0 mm.; p. 108.
10. *Macrocallista* (*Chionella?*) *gilberti* Dall; length 42.0 mm.; p. 107.



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EOCENE MOLLUSCA, ALASKA

EXPLANATION OF PLATE X

EOCENE AND MIOCENE FOSSILS

FIG. 1. *Callocardia ?* (*Pitaria ?*) *kincaidii* Dall; Miocene; length 50.0 mm.; p. 115.

2. *Trochita alaskana* Dall; Miocene; basal view of internal cast; diameter 12.0 mm.; p. 118.

3. *Modiolus alaskanus* Dall; Eocene; length 17.0 mm.; p. 106.

4. *Saxidomus popofianus* Dall; Miocene; length 50.0 mm.; p. 115.

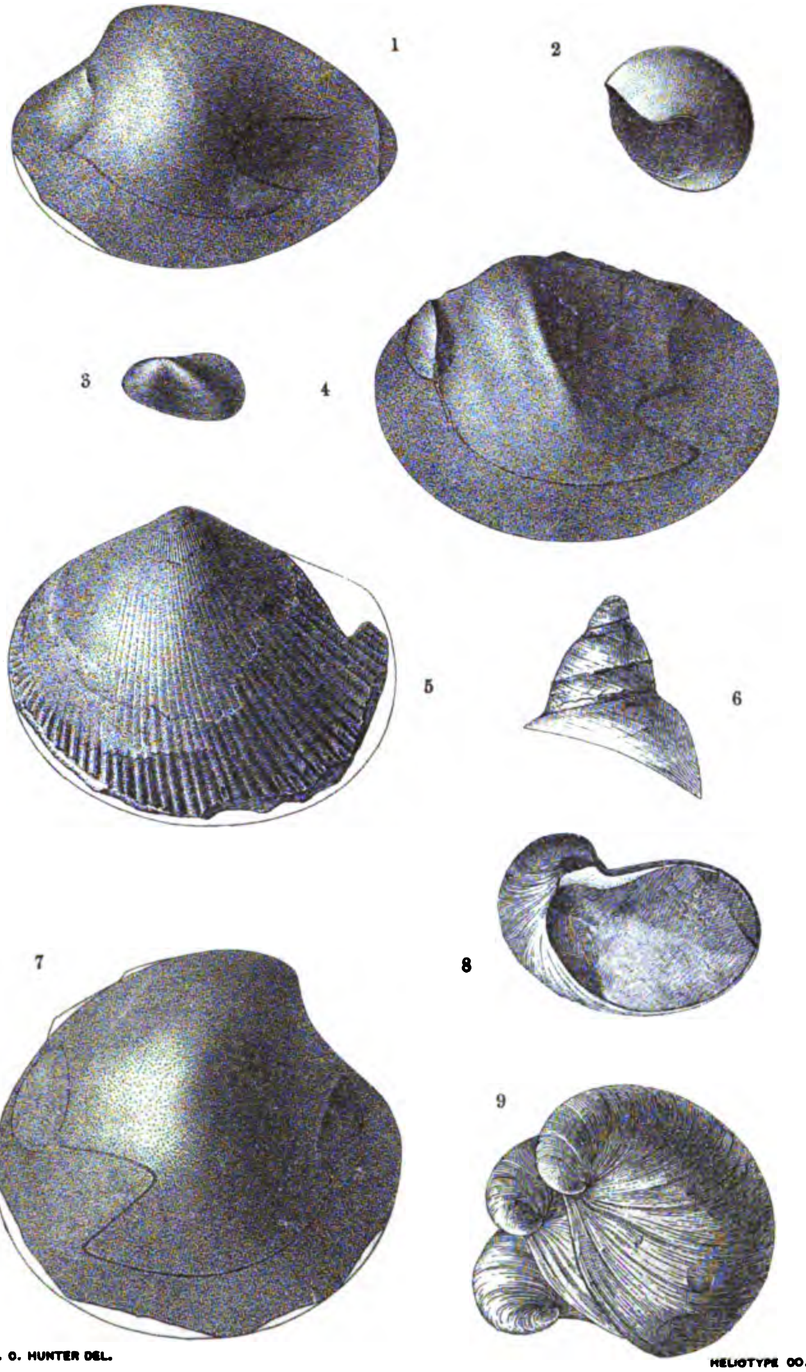
5. *Papyridea harrimani* Dall; Miocene; length 45.0 mm.; p. 113.

6. *Trochita alaskana* Dall; profile of elevated specimen; Miocene; height 20.0 mm.; p. 118.

7. *Dosinia ? alaskana* Dall; Miocene; length 55.0 mm.; p. 115.

8. *Crepidula ungana* Dall; Miocene; basal view; length 38.0 mm.; p. 119.

9. The same; three adult specimens illustrating the perching habit of this form; length of the uppermost specimen 38.0 mm.; p. 119.



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EOCENE MOLLUSCA, ALASKA

FOSSILS AND AGE
OF THE YAKUTAT FORMATION

FOSSILS AND AGE OF THE YAKUTAT FORMATION

DESCRIPTION OF COLLECTIONS MADE CHIEFLY NEAR KADIAK, ALASKA

BY EDWARD OSCAR ULRICH

DISTRIBUTION

THE collections here described and discussed are from three principal localities: Woody Island, Pogibshi Island, and the shore of Russell Fiord near Hidden Glacier. Pogibshi Island lies close to the village of Kadiak, being separated from the much larger Kadiak Island by the narrow strait constituting Kadiak Harbor. Woody Island is a few miles distant, Woody and Pogibshi being members of a group of low islands constituted wholly of slate. The Hidden Glacier locality is nearly 500 miles to the eastward. A fourth locality, about 300 miles northeast of Kadiak, is indefinite in position, being represented only by a specimen from the back of Columbia Glacier, Prince William Sound. These four localities are correlated by means of a fossil species of definite character, *Terebellina palachei*, common to them all. At one locality, that near Hidden Glacier, the containing formation has

received a name, having been called Yakutat by Russell in 1891.[1] This name, therefore, applies to the strata at all the localities.[2]

AGE

All that could hitherto be said concerning the age of the slate of the vicinity of Kadiak was that it is older than the Cenozoic, and that it is unconformably overlain, in some instances at least, by strata of early Miocene or Oligocene age. As it has an aspect denoting considerably greater age than the unquestionable Jurassic rocks underlying the Cenozoic deposits at other points along the southern coast of the peninsula, and as the only mollusk found in it was believed to be of the genus *Posidonomya*, whose known range does not extend above the Jurassic, both Dall and Hyatt suggested that the age of the slates is Triassic or older.

Dall says of them,[3] referring particularly to the exposures studied by him on Woody Island: "The fossils found are very few; one, apparently a *Posidonomya*, the only bivalve; a singular organism like a flattened *Dentalium*, but probably a worm tube; and an alga which Professor Knowlton identifies with Eichwald's *Chondrites heeri* were the most conspicuous. It is not improbable that these slates are of Triassic age, but a final determination will require more prolonged study."

In the same report, page 907, Hyatt says of the supposed *Posidonomya*, which had been referred to him and which is described in this paper as *Inoceramya concentrica*, "I should think it might be Triassic or older, but there is no solid basis for this opinion."

The quoted opinions were influenced perhaps by Fisch-

[1] An expedition to Mount St. Elias, Alaska, by Israel C. Russell: Nat. Geog. Mag., vol. III, p. 167. 1891.

[2] The statements in this paragraph, as well as other data concerning formations and localities, are on the authority of Mr. Gilbert.

[3] Report on coal and lignite of Alaska, by W. H. Dall: 17th Ann. Rept. U. S. Geol. Survey, pt. 1, p. 872. 1897.

er's identification of the Triassic *Monotis salinaria* among fossils collected by Penart from the eastern point of the peninsula at Cold Bay, Alaska. Also by the fossils collected on the southern side of the peninsula of Katmai and near the bay, reported on by Grewingk in 1850.[1] These fossils were from two horizons, one with *Ammonites wosnessenskii*, *A. biplex*, and *Belemnites paxillosus?*, the other containing a *Unio* that was somewhat doubtfully identified with *U. liassinus*.

The fossils studied and described on the following pages are referred to twelve genera and eighteen species. Thirteen of the species and seven of the genera are regarded as new, and all of the species, save the tubicolous worm and the pelecypod, are of that difficult and usually very unsatisfactory class commonly called 'fucoids.' Still, since both the worm tubes and the bivalves belong to undescribed genera, we are obliged to rely chiefly upon the evidence afforded by these supposed marine plants.

We are well aware that paleontologists are of two minds concerning the nature and origin of the majority of the fucoids, but we have not the time, nor is this the proper place, to discuss the questions. Still we may say in passing that we believe many of them are really marine plants, and that the most of the others are more than mere trails or burrows or water marks. Some of them, again, are almost certainly of the nature of sponges. It is to be understood, however, that when we speak of them as marine plants it is not because we believe they are, as a whole, of that nature, but only to obviate the frequent qualification of the words flora and plant by either a question mark or the word 'supposed.'

Following the Cambrian, in which the impressions

[1] Beitrag zur Kenntniss der orographischen und geognostischen Beschaffenheit der Nord-West-Küste Amerikas mit den anliegenden Inseln, von C. Grewingk: Verhandl. Russ. k. mineral. Gesell. zu St. Petersburg, Jahrg. 1848–1849, pp. 121, 344–347, published in 1850.

simulating some of the later fucoids, though insufficiently studied to justify a decision concerning their nature, are perhaps chiefly referable to trails of Crustacea and to inorganic causes, the American Paleozoic rocks contain but three or four notable horizons for fucoids. The first of these comprises the Frankfort and Lorraine divisions of the Cincinnati series, the second the Medina and Clinton rocks, constituting the basal members of the Silurian, the third the shaly sandstones of the Boston Group of the Lower Carboniferous of northern Arkansas. Fucoids occur in most of the other Paleozoic formations, but in the three horizons mentioned they are more abundant and much more varied in character than in any of the other divisions. Of these other divisions the Erie and Waverly shale in America and the probably nearly corresponding beds in Europe from which Ludwig and others have descibed many forms, may be mentioned as ranking next among Paleozoic formations to the Cincinnati, Medina, and Boston rocks in affording fucoids in abundance and variety.

The strata of the Coal Measures, Permian and Trias apparently everywhere are strikingly poor in fucoids, but when we reach the Lias we meet with a wealth of forms in Europe rivaling, if not exceeding, the representation in any Paleozoic horizon. In the upper Jura and middle Cretaceous they are again inconspicuous, but in the central European deposits of Eocene age, especially the Flysch of Switzerland, they occur once more in great abundance.

One of the most striking features of these successive marine floras is the extraordinary uniformity of expression running through them all. This is particularly noticeable when we compare the Ordovician types with those found in the Lias and, in a less degree, with those in the Eocene Flysch. It is true each of these horizons is distinguished by its peculiar forms, but the others, among them the

commonest, are often very similar. Thus the Ordovician *Arthraria*, *Bythotrephis*, *Paleophycus*, *Rauffella*, and certain undescribed forms, have, respectively, their corresponding types in *Fucoides moeschi* Heer, *Chondrites*, *Cylindrites*, *Cancellophycus*, and *Palæodictyon* of the Lias. One might say that this similarity in expression argues for an inorganic origin of these reappearing types. But this assertion would not be warranted, since, aside from the types peculiar to each fucoid horizon, the reappearing types are represented in each horizon by sets of species distinguishable by minor peculiarities from those of the corresponding type in another horizon; and if we could compare in these extinct marine floras the fructification and other features that are considered important in classifying recent algæ, the apparently close resemblances between the successive floras would probably resolve themselves into mere family likenesses.

Coming to a more detailed comparison of the Yakutat fucoids with those characterizing the various horizons mentioned, we find that they indicate some post-Paleozoic time, for the branching forms are of *Chondrites* and *Palæodictyon*, and not *Bythotrephis;* and the reticulated species is of *Cancellophycus*, and not *Rauffella;* while the new generic types are so far quite unknown in any of the Paleozoic fucoid horizons. Forms of the true *Helminthopsis* type also are so far unknown in Paleozoic rocks, but *Helminthoida*, though apparently restricted to the Eocene in Europe, has recently been discovered in two Lower Carboniferous horizons in Arkansas and Texas, and possibly is represented among the Silurian forms referred to *Crossopodia* McCoy *e. g.*, *C. scotica* Nicholson (? McCoy).

Now, according to the evidence of its fucoids, and assuming, of course, that we are not dealing with a new horizon, the slate of Kadiak must be referred to either the

lower Jurassic (Lias) or to the Eocene. Considering the evidence from the side of the genera represented at Kadiak, and their geologic distribution in Europe, it points perhaps quite as strongly to the Eocene as to the Lias. Thus *Helminthoida* occurs there only in the Eocene, but *Helminthopsis* belongs to the upper Lias; *Palæodictyon* is more characteristic of the Eocene Flysch than of the Jura, but the reverse is true of *Cancellophycus*, while *Chondrites* is about equally common in the upper Lias and the Flysch. Taking this generic evidence alone into account, the question of age could not be determined; but when we extend the comparison to specific alliances, and take into account the fact, already noted, that *Helminthoida* occurs in America as low as the Lower Carboniferous, the case clears up very materially.

None of the Kadiak species of *Helminthoida* are specifically identical with any of the described European species. On the other hand, *H. subcrassa*, *H. abnormis*, and *H. vaga* compare quite as closely with the unpublished Lower Carboniferous species and with the figure of the Silurian *Crossopodia scotica* published by Nicholson and Ethridge in their Monograph of the Silurian Fossils of the Girvan District in Ayrshire, as with the Eocene *H. crassa* Schafhäutl.

We describe two species of *Palæodictyon*, and both are identified with Swiss Eocene forms figured by Heer, though the larger one of the two Kadiak species has seemed to us to require separation as a variety. In these two fucoids we have the only specific evidence upon which the age of the Yakutat slate might be determined as Eocene. But carefully analyzed it turns out that even here the evidence is scarcely satisfactory, and certainly not conclusive. In the first place both *P. magnum* and *P. singulare* occur also in rocks that have been, probably erroneously, referred to the Lias. Next, at least one of

our species is not strictly the same as its European representative, *P. magnum*. Then Heer describes one insufficiently illustrated species from undoubted Liassic rocks, which is very close to *P. singulare*, and to which we might have referred the smaller of the two Kadiak species had the illustrations of the older species been as copious as those of the younger one. Finally, the specific characters of *Palæodictyon* are so vague and variable, and with the general simplicity of the fossilized plant so few, that specific identifications necessarily are more or less doubtful. Indeed, we have seen black inosculating films in the Waverly shales of Kentucky and certain Carboniferous shales in Texas that we are really at a loss to distinguish from the Eocene species figured by Heer or from the Kadiak species.

The direct evidence for the upper Liassic age of the slates under consideration is the presence in them of four European species characterizing that age, namely, *Chondrites divaricatus* F.-O., *C. alpestris* Heer, *Helminthopsis magna* H. and *H. ? labyrinthica* H. The latter genus so far is reported only from the Lias, but *Chondrites* ranges from the Lias, and possibly from the Trias, on to the Tertiary, so that the genus can be used only in determining the lower limit. The species, however, seem to be sufficiently characteristic and defined to justify considerable reliance on their evidence.

Besides the fucoids the only fossils afforded by the Kadiak localities are (1) numerous shells of a tubicolar worm and (2) several casts of a pelecypod shell. The evidence of these fossils is purely inferential, but so far as it goes it corroborates that of the upper Liassic species mentioned in the foregoing paragraph. The worm tubes, to which we have applied the name *Terebellina palachei*, compare in form with the Ordovician genus *Serpulites*, but in being composed of cemented grains of sand they

agree with *Terebella*, a living genus whose oldest known species occurs in the Liassic. The relationship being on the one hand to an Ordovician type and on the other to a Jurassic and living genus, we infer that the period of its existence must have been at some intermediate time; and since the latter relationship is doubtless the more intimate it is, especially in view of the other evidence, justifiable to assume that this period was post-Paleozoic.

The pelecypod has been called *Inoceramya concentrica*. The generic name is intended to suggest the supposed relationship of the new type, the general expression of the shell being very like that of a large *Posidonomya*, a well-marked late Paleozoic and early Mesozoic genus, and from which we believe it originated, while the vertical ligamentary pits of the hinge plate ally it to *Inoceramus*, a highly characteristic Cretaceous genus. It is just such a form as might be expected to have given rise to the last genus; while, on the other hand, its derivation from *Posidonomya* is scarcely to be questioned. Assuming that *Inoceramya* is really a connecting link between *Posidonomya* and *Inoceramus*, it is fair to assume further that it existed some time near the extinction of the earlier of those genera and before the later one attained its typical characteristics; *i. e.*, about early Jurassic or Liassic time.

After weighing, as we have, the evidence of all its known fossils, no other decision seems justifiable than that the slate of the Yakutat series is of Liassic age.

DESCRIPTIONS OF SPECIES

VERMES

Suborder TUBICOLA

Genus Terebellina gen. nov.

Long, subcylindrical, gently curved and rather thick-walled tubes, acuminate below; surface obscurely striated transversely. Tubes composed of cemented minute siliceous grains.

The general aspect of the tubular fossils for which the above generic name is proposed is greatly like that of the Ordovician *Serpulites dissolutus* Billings. On closer comparison, however, their respective compositions prove to be wholly different, the Ordovician fossils having a glossy, phosphatic or chitinous shell resembling that of a *Lingula*, while the Alaskan tubes under consideration are composed chiefly of quartz and feldspar grains, with an occasional shred of colorless mica. Thin sections show that their constituents are essentially the same as those of the arenaceous shale in which they are found, the main difference being that the grains are of more uniform and larger average size in the tubes than in the matrix.

In having a shell composed of cemented sand grains *Terebellina* suggests Cuvier's *Terebella*, a genus of tubicolous worms living in the present seas but recognized also in the Liassic and Upper Jurassic of Germany. The tubes of *Terebella*, however, are more irregular in their growth and, so far as we could learn, are always composed of coarser grains; and the latter differ further in being calcareous instead of siliceous. Possibly the last difference has no structural significance and is due solely to the mineralogical character of the sand grains available to the worm in building its tubular investment. Whether this is true or not, we believe the affinities of the new genus are nearer *Terebella* than either *Serpula* or *Serpulites*.

Terebellina palachei sp. nov.

Pl. XI, figs. 1–7.

Tube long and narrow, subcylindrical, expanding very gradually from the acuminate lower extremity; about two-thirds of the diameter is taken up by the central hollow. In the majority of the specimens the greatest diameter does not exceed 2.3 mm., and some of these must have had a length of over 15 cm. A number of fragments, however, have a diameter of from 3.5 mm. to 4.5 mm., but as the collection affords no satisfactory intermediate sizes we are not prepared to say positively that these larger fragments belong to the same species. The surface of most of the specimens presents no markings save a few widely separated constrictions and annulations, and more numerous transverse furrows or slits that seem to be due to weathering. On a few of the better preserved fragments, however, the surface exhibits more or less obscure and closely arranged transverse striæ.

As preserved, the specimens nearly always present clear evidence of compression, the tube being in most cases cracked lengthwise. As a rule the slabs of slightly arenaceous slate or shale on and in which

the tubes occur contain no other evidence of either animal or vegetable remains.

Dr. W. H. Dall collected the first specimens of this fossil, and mentions it in his Report on Coal and Lignite of Alaska (Seventeenth Annual Report United States Geological Survey, part 1, page 872). He speaks of it as "a singular organism like a flattened *Dentalium*, but probably a worm tube."

Named for Dr. Charles Palache, one of the geologists of the Expedition.

Localities.—Most of the specimens are from Pogibshi Island, opposite the village of Kadiak. Others came from near Hidden Glacier, at Russell Fiord of Yakutat Bay, and from Woody Island, near the station of the North American Commercial Company, while a single example was secured from a boulder in the moraine of Columbia Glacier, Prince William Sound.

Collectors.—W. H. Dall, G. K. Gilbert, B. K. Emerson, Charles Palache.

MOLLUSCA

PELECYPODA

Genus **Inoceramya** gen. nov.

Shell resembling that of a *Posidonomya*, apparently equivalve, thin, compressed, concentrically waved; hinge margin straight, long, edentulous, but bearing on its central part several small but long vertical ligamentary pits, and behind these, possibly to the end of the hinge, numerous shorter and gradually diminishing pits; post-cardinal region compressed, obtusely wing-like, distinguished externally from the concentrically waved body of the valve by finer and somewhat differently directed striation and internally by a rib-like thickening extending obliquely backward from the beaks toward the middle of the dorsal half of the posterior margin; anterior part of hinge unknown; beaks subcentral, not large.

The systematic position of this genus may be said to be intermediate between *Posidonomya* Bronn and *Inoceramus* Sowerby, though it has certain characters not possessed by either of the two genera mentioned. From the former it is distinguished by having ligamentary pits; from the latter by the absence of the prismatic inner shell layer that is so highly characteristic of Sowerby's genus, and in having the hinge plate wider and the ligamentary pits longer in the region of the beaks. Continuing the comparison, we find that the characters pertaining to the wing-like post-cardinal region of the new genus are not present in either of the old genera.

Considering the importance of the genus as a probable connecting link between the Paleozoic and early Mesozoic *Posidonomya* and the chiefly Middle and Upper Cretaceous genus *Inoceramus*, it is unfortunate that the material upon which the new genus is founded is not more complete and better preserved. Still, by careful preparation it has been made to show sufficient characters to give us a fairly good idea of the shell that left the impressions.

Inoceramya concentrica sp. nov.

Pl. XII, figs. 1, 2; Pl. XIII, fig. 1.

Shell broad-ovate, slightly oblique, with the hinge margin long and straight; anterior cardinal margin probably nearly rectangular, post-cardinal margin sharply rounded and forming a wider angle; anterior and ventral portions of outline nearly semicircular. Valves depressed convex; beaks small, situated anterior to the center; umbonal ridge inconspicuous. Surface concentrically waved, the average width of the undulations increasing with age from 1 mm. or 2 mm. on the umbones to 4 mm. or 5 mm. on the central and ventral parts of adult shells. The concentric undulations do not cross the compressed elongate triangular posterior wing, but cease along a line separating the wing from the body of the valve. The wing itself is marked by much finer and rather obscure striæ. Hinge plate wide just beneath the beaks, where a specimen broken off at this point (see pl. XII, fig. 2) shows two long vertical ligamentary pits and behind these a series of shorter and gradually diminishing pits that may be traced beyond the middle of the distance to the post-cardinal extremity. Immediately beneath this pitted margin there is a narrow depression, becoming obsolete posteriorly, and beneath this the heavy, posteriorly widening interior rib marking the separation of the wing from the body of the shell. This begins just behind the beak and dies out as it widens, becoming quite obsolete before reaching the posterior margin. Muscular scars and pallial line not observed.

Dr. W. H. Dall, who discovered the specimens above described, refers to the species as 'apparently a *Posidonomya*' in his Report on Coal and Lignite of Alaska (page 872 of the Seventeenth Annual Report of the United States Geological Survey). Though we have shown already, in our remarks on the new genus that we have believed it necessary to establish for their reception, why they should not be referred to *Posidonomya*, we may repeat that besides the ligamentary pits, which are absent in true species of that genus, the internal rib in

the post-cardinal region of *I. concentrica* constitutes another feature so far unknown in *Posidonomya*.

Locality.—Woody Island, Kadiak, on the shore facing Chiniak Bay, Alaska.

Collector.—W. H. Dall.

FUCOIDES

Genus **Chondrites** Sternberg.

Chondrites divaricatus Fischer-Ooster.

Pl. XVI, figs. 1, 2.

Chondrites divaricatus FISCHER-OOSTER, Foss. Fucoiden, p. 45, 1858.—HEER, Flora Foss. Helvetiæ, p. 107, taf. XLI, figs. 6, 7, and taf. XLII, figs. 11, 12, 1877.

Two specimens in the material gathered at Kadiak Island appear to fall within the limits of this species. They occur as delicate, slightly glossy, black, widely divaricating ramulets in an arenaceous slate. The branching stems have a width of from 0.45 mm. to 0.6 mm., and divide both dichotomously and pinnately at frequent though variable intervals. The lateral divisions are short and not appreciably thickened at their extremities.

In one of the two specimens the stems are a trifle thinner and the divisions more abundant than in the other. This approaches *C. intricatus* (Brongniart) Heer, a common Eocene fossil in Switzerland and elsewhere in Europe, yet not near enough to justify its separation from *C. divaricatus*. The latter is not uncommon in the Upper Lias of central Europe.

Locality.—Pogibshi Island opposite the village of Kadiak, Alaska.

Collectors.—G. K. Gilbert, B. K. Emerson, Charles Palache.

Chondrites alpestris Heer.

Pl. XVIII, fig. 4.

Chondrites alpestris HEER, Flora Foss. Helvetiæ, p. 109, taf. XLII, figs. 13–16, 1877.

Plant cæspitose, apparently not spreading in one plane but giving off branches in all directions; divisions very frequent, diverging very slightly, oftener dichotomous than pinnate; branches varying from 0.5 mm. to 1.0 mm. in width, apparently terminating obtusely.

C. alpestris is so strikingly different from nearly all the other species of this prolific genus, and at the same time is signalized by such obvious peculiarities, that we have no doubt concerning the close relations, if not the identity, of the Alaskan specimen here described

and figured with the Swiss Upper Liassic types of the species. Our specimen is a hollow mold of the exterior in a slaty sandstone.

Locality.— Pogibshi Island, opposite the village of Kadiak, Alaska.
Collectors.— G. K. Gilbert, B. K. Emerson, Charles Palache.

Genus **Palæodictyon** Heer.

Palæodictyon magnum laxum subsp. nov.

Pl. xv, fig. 1.

Cfr. *Palæodictyon magnum* Heer, Flora Foss. Helvetiæ, p. 160, taf. lxiv, fig. 9, 1877.

The remains of this plant appear as glossy, flat, irregularly convoluted, rarely inosculating bands 2 mm. to 3 mm. wide, on fresh surfaces of a dark slate. The bands evidently are mere fragments that originally may have been connected to form a very loose and irregularly meshed network.

At first sight we were inclined to refer these Alaska specimens to Heer's *P. magnum* without qualification, they being perhaps sufficiently like certain portions of the figure published by Heer of this Eocene (Flysch) species to justify their identification. Closer comparisons, however, satisfied us that the growth of the Alaskan form was more irregular and very loosely reticulated, so that it seems advisable to distinguish it as a subspecies at least.

Locality.— Woody Island, near the village of Kadiak, Alaska.
Collector.— W. H. Dall.

Palæodictyon singulare Heer.

Pl. xv, fig. 2.

Palæodictyon singulare Heer, Urwelt der Schweiz, p. 245, taf. x, fig. 10, 1865,—and Flora Foss. Helvetiæ, p. 160, taf. xliii, fig. 21, taf. lxiv. figs. 5–8, 1877.

This delicate form is associated with *P. magnum* var. *laxum*, but will be distinguished at a glance by its smaller size and much closer intertwinings. The bands usually are a trifle less than 1 mm. wide and but rarely exceed that width, and they bend in and out and over oue another so rapidly that they appear to form a close but always very irregular network.

This form has seemed to us to agree too well with some of Heer's figures of *P. singulare* to be distinguished even as a variety. In Switzerland the species occurs, sometimes in association with *P. mag-*

num and *P. textum*, in the shales of the Flysch formation, generally regarded as of Eocene age, and possibly also in the Liassic.[1]

Locality. — Woody Island, Kadiak.

Collector. — W. H. Dall.

Genus **Arthrodendron** gen. nov.

Plant ramose, bushy, the branches constricted at regular intervals and probably consisting each of a series of rounded or ovate, flattened (originally inflated) joints; surface of joints minutely granopunctate.

This marine plant may have some relation to *Cymopolia* Lamouroux and *Corallina* Linn., but instead of a thick calcareous incrustation the joints appear to have had a leathery carbonaceous cover that, in consequence of the compression the plants have suffered in common with the mud in which they were entombed, is now thickened around the edge of each joint and more or less wrinkled in the flattened space inclosed by the marginal rim. The substance of the plant, which is believed to have been carbonaceous, because of its dull polish and dark color, is readily distinguished from the grayish-black shale in which the specimens are embedded.

The jointed or beaded character of the branches, coupled with their carbonaceous composition, recalls an Eocene (Flysch) species from Switzerland that Heer refers to the recent genus *Hormosira* Harvey. In the fossils before us, however, the joints appear to be of one kind only, whereas in *Hormosira* two sets — one narrow and sterile, the other wider, subglobular, and fertile — are distinguishable.

Arthrodendron diffusum sp. nov.

Pl. xiv, figs. 1–3.

Branches moniliform, springing from a central point and spreading outwardly and upwardly so as to form a loose bush-like mass as much as 15 cm. in diameter; divisions dichotomous, at intervals varying from 6 mm. to over 20 mm. Joints subelliptical, the lower half usually a little narrower than the upper half, 4 mm. to 6 mm. in length and from 2.2 mm. to 2.8 mm. in width; surface usually glossy and smooth, but where the preservation is more favorable is covered by minute granules and punctæ.

[1] Both *P. singulare* and *P. textum* were identified by Heer in rocks, formerly at least, referred to the Lias. In the Flora Fossilis Helvetiæ, however, he doubts the Liassic age of the beds, and seems to favor the view of Escher, who had previously suggested that they belong to the Eocene. Whether this later view has been substantiated by more recent investigations we can not say.

Locality.—Pogibshi Island, opposite the village of Kadiak, Alaska.
Collector.—G. K. Gilbert.

Genus **Cancellophycus** Saporta.

Cancellophycus rhombicum sp. nov.

Pl. xx, fig. 1.

Of this fossil the collections before us contain only the specimen figured on pl. xx. It lies on the flat surface of a block of slate and probably represents only a part of an originally much larger expansion. That this was ever sack-like in form, as is believed of the typical species of *Cancellophycus*, is very doubtful. Instead, the evidence of the specimen all tends toward proving that it was originally a large, simple, flabelliform expansion. This probable difference in growth might justify another generic arrangement, but as some at least of the species referred to the genus by Saporta indicate a similar habit of growth, and as the general structure agrees very well with that of the species in mind, notably *C. reticulare* Sap., it seems best, for the present at least, to refer the Alaskan species to the same genus.

The surface of the specimens is covered with branching and interwoven knotted ribs and threads, leaving, according to the degree of regularity in which they cross or unite with one another, either elongate shapeless meshes or more or less regularly rhomboidal ones. Along the lower edge the ribs are very much stronger, and here the bifurcations are numerous, the size of the branching threads being soon reduced to an average thickness of less than 0.5 mm. The meshes exhibit a fine longitudinal striation.

C. rhombicum seems to be closely related to *C. reticulare* Saporta,[1] from the Lower Oolite of the Jurassic of France. It may be distinguished, however, at once by the much greater delicacy of its ribs and smaller rhomboidal meshes.

Locality.—Pogibshi Island, opposite the village of Kadiak.
Collectors.—G. K. Gilbert, B. K. Emerson, Charles Palache.

Retiphycus hexagonale gen. et sp. nov.

Pl. xviii, fig. 5.

Plant? forming retiform expansions of unknown dimensions; meshes somewhat irregularly hexagonal, averaging six in 25 mm.; separating walls about 1.0 mm. thick, rounded.

The composition of this fossil seems to be precisely as in the other 'fucoids' found at Kadiak, and if the latter are to be regarded as

[1] Pal. Franc., 2° ser., Veg., T. 1, p. 142, pls. 7 et 8, fig. 1, 1873.

remains of marine algæ it is fair to assume that this also is of that nature. There may be recent algæ with which it might be compared, but we know of none reticulated like this one among the fossil forms.

Locality.—Pogibshi Island opposite the village of Kadiak, Alaska.

Collectors.—G. K. Gilbert, B. K. Emerson, Charles Palache.

Genus **Gyrodendron** gen. nov.

Plant consisting of apparently solid cylindrical stems, bifurcating one or more times, and enrolled in one plane so as to form one or perhaps two volutions; inner extremity somewhat acuminate, outer ends obtuse.

In the absence of any characters beyond the mere form we must place this peculiar type with such other supposed remains of algæ as *Cylindrites*, *Helminthoida* and *Helminthopsis*, from all of which it is at once distinguished by its spiral habit of growth. Whether the stems were originally solid or hollow can not be decided now. As preserved, their composition is generally quite different from that of the matrix in which they are embedded.

Gyrodendron emersoni sp. nov.

Pl. XVIII, fig. 3; Pl. XIX, figs. 1, 2.

Stems varying in thickness from 2.5 mm. to 6.0 mm., bifurcating once, twice or three times, all apparently becoming more robust with age and forming from one to one and two-thirds volutions about the acuminate inner extremity. In the larger examples the concentric curve of the outer ends of the branches is gradually lessened until they become approximately straight and appear to run off at a tangent.

This striking and easily recognized fossil is named in honor of the eminent geologist, Prof. B. K. Emerson.

Locality.— Pogibshi Island, opposite the village of Kadiak, Alaska.

Collectors.— G. K. Gilbert, B. K. Emerson, Charles Palache.

Genus **Gilbertina** gen. nov.

Plants ? consisting of a double cord wound in a close spiral like the spring of a watch. As preserved, the fossils present the appearance of a slender coiled tube cut in half horizontally.

This remarkable fossil can at present be compared only with *Helminthoida* Schafhäutl, though we are not by any means satisfied that there is any true relationship between them. Much might be said upon the possible relations of *Gilbertina*, and also concerning other interpretations of its fossil remains, but it may all very well be post-

poned to some future occasion when we hope to discuss the 'fucoids' as a whole. For the present it will suffice to state that the spiral habit of growth is the character principally relied on in distinguishing the genus from the other unbranched fucoids. The much more robust *Cylindrites convolutus* Fischer-Ooster, from the Eocene of the Alps, also grows in a spiral manner, but in this case the spiral is formed by a single cord and not by two parallel cords.

The name is from that of the discoverer, Mr. G. K. Gilbert, who also collected most of the other fossils obtained by the geologists of the Expedition from Pogibshi Island.

Gilbertina spiralis sp. nov.

Pl. XVIII, figs. 1, 2.

The spirally coiled slender stem begins with an open loop, the two ends of which soon begin to curve inward and, maintaining a nearly parallel curve with respect to each other and preceding volutions, continue until they cover a subcircular space 5 to 8 cm. in diameter. The concave spaces between the coils of the stem increase in width as growth proceeds, from about 1.2 mm. to about 2.5 mm., while the thickness of the stem itself remains nearly constant at about 1.0 mm.

Perhaps it would be nearer the truth to consider the raised coils of the fossil as matrix filling the interstices between an originally hollow and now compressed cylinder. Under this interpretation the structure at the center of the coil would necessitate the assumption that the impressions were formed by two equal but separate cylinders. This was the view that first suggested itself, but the difficulty of explaining the irregularity of the outer one or two of the raised coils exhibited by two of the specimens before us could not be satisfied except by the interpretation adopted above.

Locality.— Pogibshi Island, opposite the village of Kadiak, Alaska.

Collector.— G. K. Gilbert.

Genus **Helminthoida** Schafhäutl.

Helminthoida SCHAFHÄUTL., Geognostische Untersuch. des südbayer. Alpengebirges, p. 142, 1851.—HEER, Urwelt der Schweiz, p. 246, 1865, and Flora Foss. Helvetiæ, p. 167, 1877.

Among the problematical fossils before us are four varieties of a type that in part at least corresponds very closely with the one for which Heer proposed the name *Helminthoida*. The first and the second of these varieties may be referred to this genus without reserve, but the third and fourth varieties depart from the normal forms of the genus

in the much less regular convolution of the cord-like fossil. The trend of the variation is toward *Helminthopsis* Heer, and *Helminthoida vaga* might, with perhaps equal propriety, be referred to that genus.

Heer describes four species of *Helminthoida* from the Eocene of Switzerland, and so far as we know the genus has not been heretofore met with in older rocks.[1] One of Heer's species, *H. appendiculata*, presents a peculiarity in the appendical prolongation of the closed end of the loops, but in other respects resembles *H. vaga* of this paper. Our *H. subcrassa* and *H. exacta* may be compared with Schafhäutl's *H. crassa*, but both are distinguished by obvious differences. As to *H. abnormis*, it stands somewhat apart, yet may be compared with certain varieties of *H. labyrinthica* Heer.

Concerning the nature of these and other trail-like fossils, we are wholly satisfied of their organic origin, while the fact that they often lie *over* each other and sometimes are piled together like tangled cords, proves, we believe, conclusively that they are not trails. Considering their organic nature as established, some provisional position must be assigned to them in nature until something definite concerning their structure may be learned. In the mean time we are quite willing to follow Heer and others, who view them provisionally as marine plants, despite the fact that no corresponding algæ are known in the present seas.

Helminthoida exacta sp. nov.

Pl. XVI, fig. 5.

The remains of this supposed marine plant resemble a convoluted cord, about 1.5 mm. in thickness, folded very regularly so as to form equal, narrow, slightly curved loops about 18 mm. in depth and averaging 1.5 mm. in width. The imperfect specimens at hand indicate that as growth proceeded the successive loops increased very gradually in length.

Locality.—Pogibshi Island, opposite the village of Kadiak, Alaska.

Collectors.—G. K. Gilbert, B. K. Emerson, Charles Palache.

Helminthoida subcrassa sp. nov.

Pl. XVI, fig. 3.

The form for which this name is proposed is represented by a

[1] Since the above was written the author has discovered two large species apparently of this genus, one in the Batesville Sandstone of the Lower Carboniferous rocks of Arkansas, the other in the somewhat younger Strawn Formation of Texas. This fact and the possible relations to *Crossopodia* are noted *ante*, page 129.

specimen composed of seven successive loops. Of these the first is >-shaped and considerably shorter and wider than the last three or four. The cord decreases in average thickness from below upward, the extreme measurements being 2.7 mm. and 2.0 mm.

Distinguished from *H. exacta* by its more robust aspect and less regular convolutions. From *H. crassa* Schafhäutl, from the Eocene of Switzerland, with which it agrees in size of the cord, it differs in forming much shorter loops.

Locality.—Pogibshi Island, opposite the village of Kadiak, Alaska.

Collectors.—G. K. Gilbert, B. K. Emerson, Charles Palache.

Helminthoida abnormis sp. nov.

Pl. XVI, fig. 4.

In this species the windings of the cord, which often appears to be crimpled and here and there knotted, and varies from 1.2 mm. to nearly 2.0 mm. in thickness, form very irregular and unequal loops. The latter, however, can scarcely be called vagrant, since, despite their irregularity, they seem to be confined to a space of nearly definite width.

Distinguished from the preceding species by the irregular intertwining of the cord and its slightly knotted and crimpled character. The same peculiarities separate it from all of Heer's species, among which the usually much more delicate *H. labyrinthica* presents perhaps more points of resemblance than any other known species.

Locality.—Pogibshi Island, opposite the village of Kadiak, Alaska.

Collectors.—G. K. Gilbert, B. K. Emerson, Charles Palache.

Helminthoida vaga sp. nov.

Pl. XVII.

In this form the cord, which averages about 2.2 mm. in diameter, forms several large and more or less irregular loops or folds and then becomes vagrant, the succeeding turns being without order and having, apparently, no relation to the preceding loops.

Fragments of this species appear to be abundant, but, on account of the large size and straggling habit of growth, good and approximately entire specimens are likely to prove rare. Compared with other species of the genus, and especially those found with it in Alaska, it is distinguished at once by its large size and vagrant habit. Small fragments might be confounded with *Helminthopsis ? labyrinthica* Heer, but with more complete examples this is not likely to occur.

Locality.—Pogibshi Island, opposite the village of Kadiak, Alaska.

Collectors.—G. K. Gilbert, B. K. Emerson, Charles Palache.

Genus **Helminthopsis** Heer.

Helminthopsis magna Heer.

Pl. XXI, figs. 1, 2.

Helminthopsis magna HEER, Flora Foss. Helvetiæ, p. 116, taf. XLVII, figs. 1, 2, 1877.

Fucoid originally cylindrical and tubular, now flattened, several feet in length, 12 mm. to 25 mm. in width, the edges thickened, forming serpentine convolutions over the surface of slabs of arenaceous slate. The larger of the two specimens before us exhibits distinct transverse wrinkles, while on portions of the smaller specimen longitudinal lines as well as obscure transverse undulations may be discerned.

Heer described the surface of his specimens as smooth, and the thickened margins of the compressed tubes are heavier in his figures than in the Alaska specimens under consideration. Despite these differences we believe the latter belong, if not strictly to the same species, at least to one so near the Swiss Upper Liassic form that we are not at present warranted in separating it. Possibly the differences are due to faulty observation or to the less favorable preservation of Heer's originals. However, this point may turn out, it is certain his figures look very much like our specimens.

Locality.—Pogibshi Island opposite the village of Kadiak (? also Woody Island), Alaska.

Collector.—G. K. Gilbert.

Helminthopsis ? labyrinthica Heer.

Pl. XX, figs. 2, 3.

Helminthopsis labyrinthica HEER, Flora Foss. Helvetiæ, taf. XLVII, figs. 3–5, 1877.

This fossil consists of simple, smooth, cylindrical, stony cords 1.8 mm. to 2.5 mm. in thickness, meandering, in the cases before us, over the surface of arenaceous slates. The stems are usually thrown into more or less irregular and unequal loops, often horseshoe-shaped, and sometimes recalling the more regularly formed loops of *Helminthoida*.

The Alaskan specimens under consideration agree so closely with Heer's figures of the Swiss Upper Liassic specimens upon which he founded the species *H. labyrinthica* that we can not doubt they belong to the same species. As to the propriety of referring the species to *Helminthopsis*, we are inclined to differ from the able author of the Flora Fossilis Helvetiæ. Considering *H. magna* as the type of the genus, *Helminthopsis* should be restricted to species having the con-

EXPLANATION OF PLATE XI

FOSSIL ANNELID TUBES FROM WOODY AND POGIBSHI ISLANDS, NEAR KADIAK VILLAGE, ALASKA

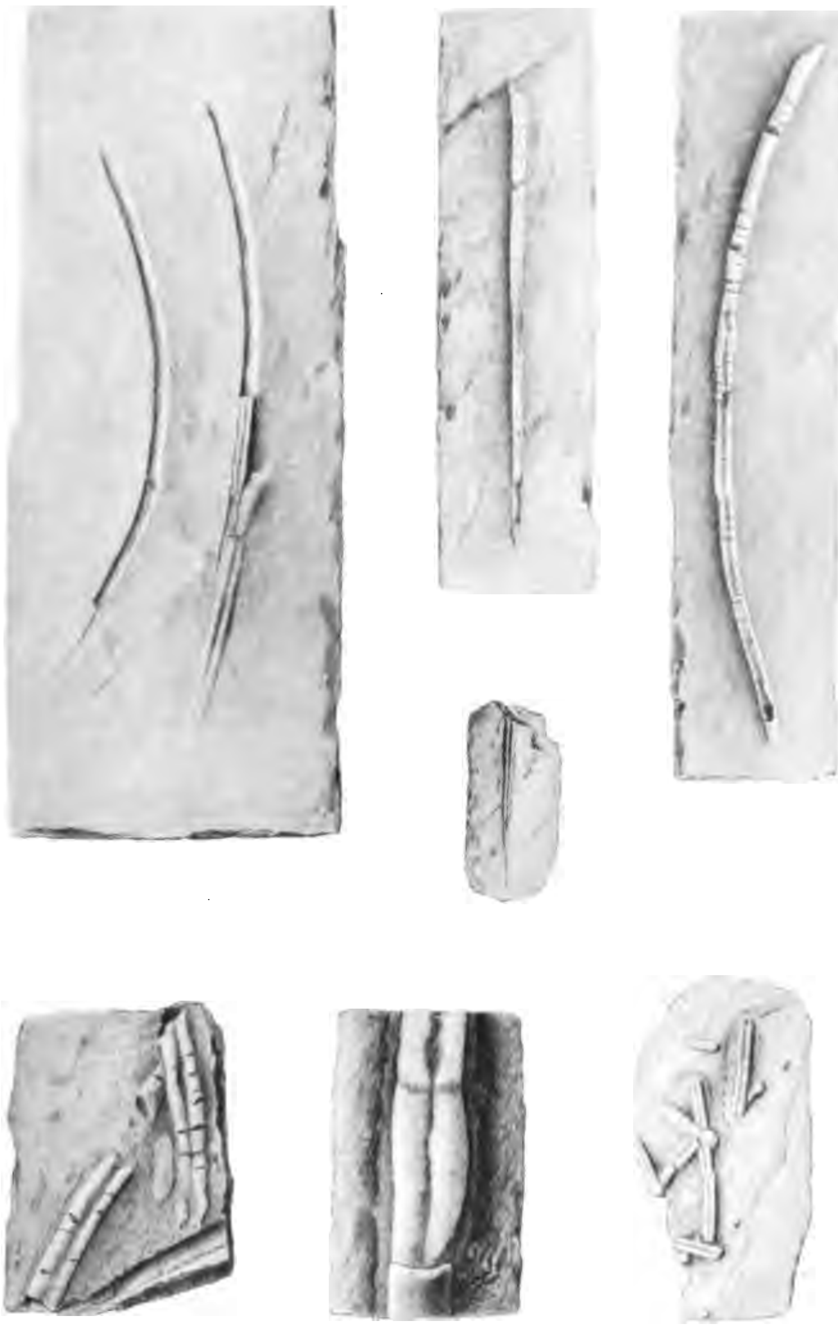
Natural size, except figure 6

FIGS. 1–7. *Terebellina palachei* gen. et sp. nov. Page 132.

1. Two curved specimens of this worm tube; incomplete and represented in part by the impression only.
2. A weathered tube, the lower half showing the interior hollow.

3 and 4. Two specimens, the first retaining the greater part, the second all of the acuminate proximal extremity.

5. A number of fragments in soft shale.
6. Portion of a specimen showing constrictions and faint transverse lines; × 5.
7. Several fragments of the large form mentioned in the description.



YAKUTAT FORMATION, NEAR KADIAK, ALASKA

TEREBELLINA PALACHEI gen. et sp. nov.

EXPLANATION OF PLATE XII

FOSSIL PELECYPOD FROM POGIBSHI ISLAND, NEAR KADIAK VILLAGE, ALASKA

FIGS. 1 and 2. *Inoceramya concentrica* gen. et sp. nov. Page 135. (See also plate XIII.)

1. Gutta percha cast of the natural mold of the exterior figured on plate XIII; restored in outline. Natural size.
2. Gutta percha cast of a natural mold of the interior ($\times$ 1.5), showing the posterior half of the hinge and the interior rib.

1

2 x 1.5

YAKUTAT FORMATION, WOODY ISLAND, ALASKA

INOCERAMYA CONCENTRICA gen. et sp. nov.

EXPLANATION OF PLATE XIII

FOSSILS FROM WOODY ISLAND, NEAR KADIAK VILLAGE, ALASKA

Natural size

FIG. 1. *Inoceramya concentrica* gen. et sp. nov. Page 135. (See also plate XII.)

Portion of a large slab containing the impressions of both interior and exterior surfaces of imperfect valves upon which this species and genus are found.

2. *Myelophycus curvatum* gen. et sp. nov. Page 145.

Three specimens of this fucoid greatly compressed. The lower specimen is weathered so as to expose the edges and sections of the invaginated conical cups making up the interior portion.

2

Frank ... Del. Heliotype Co.

YAKUTAT FORMATION, WOODY ISLAND, ALASKA

1 INOCEROMYA 2 MYELOPHYCUS

EXPLANATION OF PLATE XIV

FOSSIL MARINE PLANT FROM POGIBSHI ISLAND, NEAR KADIAK VILLAGE, ALASKA

Natural size, except figure 3

FIGS. 1–3. *Arthrodendron diffusum* gen. et sp. nov. Page 138.

1. A nearly complete specimen showing the mode of growth and the beaded or jointed character of the branches.
2. Several fragments on another piece of shale.
3. One of the flattened elliptical joints of the preceding specimen ($\times$ 9), showing surface markings.

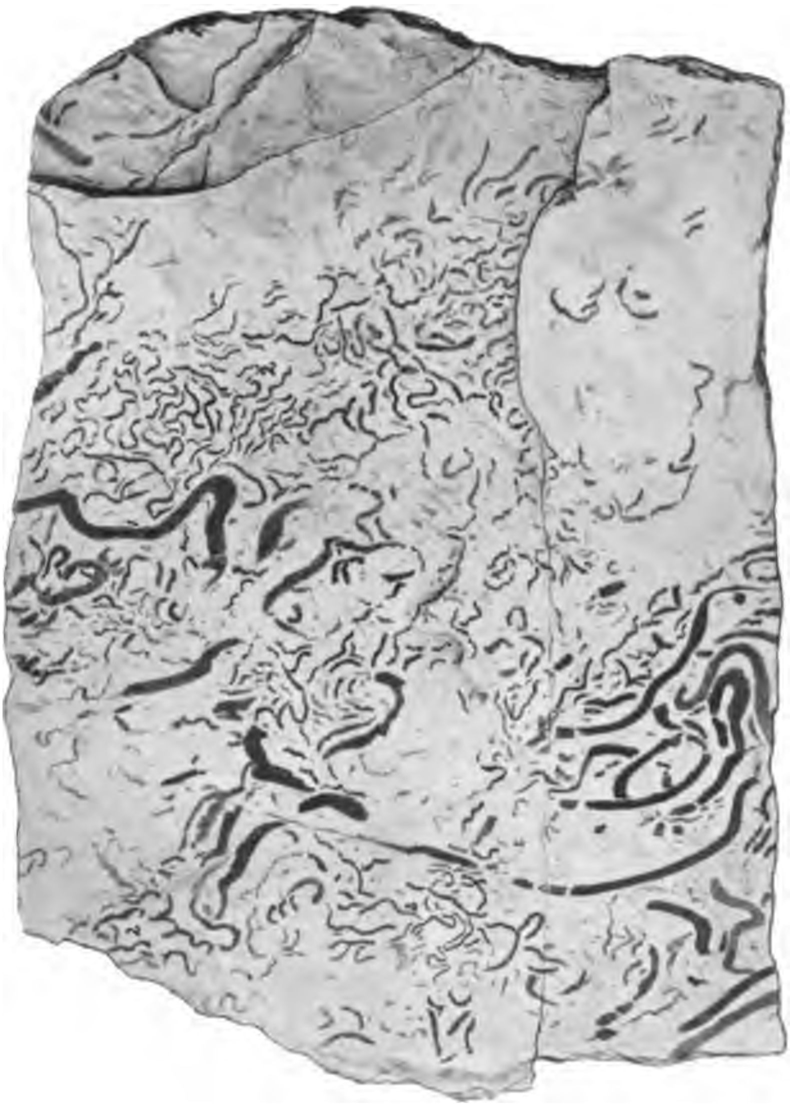
YAKUTAT FORMATION, POGIBSHI ISLAND, ALASKA

ARTHRODENDRON DIFFUSUM gen. et sp. nov.

EXPLANATION OF PLATE XV

FOSSIL FUCOIDS FROM WOODY ISLAND, NEAR KADIAK, ALASKA
Four-fifths natural size

The greater part of a slab of slate nearly covered with two species of *Palæodictyon* described on page 137. The larger form (1) is *P. magnum laxum* sp. nov., the smaller (2) *P. singulare* Heer.



YAKUTAT FORMATION, WOODY ISLAND, ALASKA

PALÆODICTYON

EXPLANATION OF PLATE XVI

FOSSIL FUCOIDS FROM POGIBSHI, NEAR KADIAK, ALASKA
Natural size

FIGS. 1 and 2. *Chondrites divaricatus* Fischer-Ooster. Page 136.

1. A specimen having more delicate branches than usual.
2. A specimen agreeing very nearly with the normal form of the species.
3. *Helminthoida subcrassa* sp. nov. Page 142.

View of the specimen described.

4. *Helminthoida abnormis* sp. nov. Page 143.

The greater part of the specimen chiefly consulted in drawing up the description of this species. It is somewhat weathered and the nodular character of the cord is best shown on the portion not included in the figure.

5. *Helminthoida exacta* sp. nov. Page 142.

One of the two specimens upon which this species is founded.

1

3

2

4

5

Frances Wieser Del.

Heliotype Co.

YAKUTAT FORMATION, POGIBSHI ISLAND, ALASKA

1, 2 CHONDRITES 3, 4, 5 HELMINTHOIDA

EXPLANATION OF PLATE XVII

FOSSIL FUCOID FROM POGIBSHI ISLAND, NEAR KADIAK VILLAGE, ALASKA

Natural size

Helminthoida vaga sp. nov. Page 143.

Surface of a slab of slate showing the irregularity of folds that is regarded as characteristic of the species.

Frances Wieser Del

Heliotype Co.

YAKUTAT FORMATION, POGIBSHI ISLAND, ALASKA

HELMINTHOIDA VAGA sp. nov.

EXPLANATION OF PLATE XVIII

FOSSIL FUCOIDS FROM POGIBSHI ISLAND, NEAR KADIAK VILLAGE, ALASKA

Natural size

FIGS. 1 and 2. *Gilbertina spiralis* gen. et sp. nov. Page 141.

1. The largest specimen seen. The elliptic outline probably is due to compression.
2. The smallest specimen in the collection. It is important because of the irregular folds of the outer whorls.
3. *Gyrodendron emersoni* gen. et sp. nov. Page 140. (See also plate XIX.)
   A small specimen, considering that it is three times bifurcated.
4. *Chondrites alpestris* Heer. Page 136.
   View of the only specimen of this species seen. It is an empty mold of the exterior.
5. *Retiphycus hexagonale* gen. et sp. nov. Page 139.
   View of the unique specimen upon which this genus and species is founded. The specimen is restored in the shaded central part of the figure.

2 5

YAKUTAT FORMATION, POGIBSHI ISLAND, ALASKA

1, 2 GILBERTINA 3 GYRODENDRON 4 CHONDRITES 5 RETIPHYCUS

EXPLANATION OF PLATE XIX

FOSSIL FUCOIDS FROM POGIBSHI ISLAND, NEAR KADIAK VILLAGE, ALASKA

Natural size

FIGS. 1 and 2. *Gyrodendron emersoni* gen. et sp. nov. Page 140. See also plate XVIII.

1. A slab containing several specimens in different stages of growth.
2. Two specimens with thicker branches, possibly belonging to another species of this remarkable genus of fucoids.

1

2

YAKUTAT FORMATION, POGIBSHI ISLAND, ALASKA

GYROLENDRON EMERSONI gen. et sp. nov.

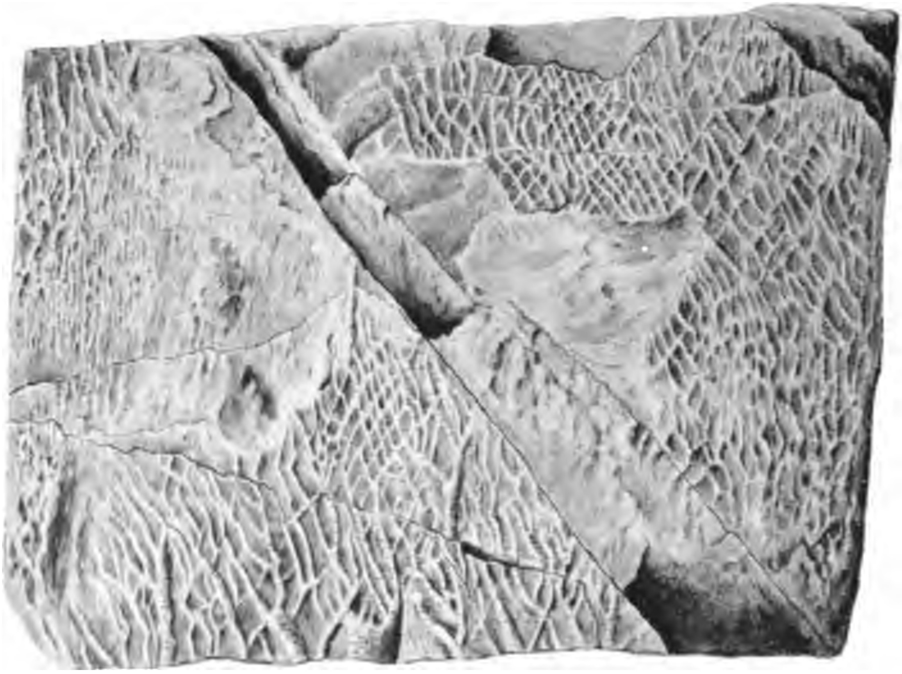
EXPLANATION OF PLATE XX

FOSSIL FUCOIDS FROM POGIBSHI ISLAND, NEAR KADIAK VILLAGE, ALASKA

Natural size

FIG. 1. *Cancellophycus rhombicum* sp. nov. Page 139.
View of the specimen described.

2 and 3. *Helminthopsis ? labyrinthica* Heer. Page 144.
Portions of two slabs with fragments of this species.



1

2

3

Frances Wieser Del. Heliotype Co.

YAKUTAT FORMATION, POGIBSHI ISLAND, ALASKA

1 CANCELLOPHYCUS 2, 3 HELMINTHOPSIS?

EXPLANATION OF PLATE XXI

FOSSIL FUCOIDS FROM POGIBSHI ISLAND, NEAR KADIAK VILLAGE, ALASKA

Natural size

FIGS. 1 and 2. *Helminthopsis magna* Heer. Page 144.

1. A small specimen of the Alaskan form of this species. The surface appears to be in a better state of preservation than on the Swiss types of the species.
2. A small portion of a slab containing a larger and wider specimen; figured to show corrugations of surface.

YAKUTAT FORMATION, NEAR KADIAK, ALASKA

HELMINTHOPSIS MAGNA Heer.

voluted cylindrical stem originally hollow. *H. labyrinthica*, on the contrary, was almost certainly solid. What to do with the latter we are not prepared to say, although we have provisionally referred what we believe is a congeneric species to *Helminthoida* under the name of *H. vaga*. So far as we can see the latter is distinguished from *H. labyrinthica* only by its much longer loops and generally looser habit of growth.

Locality. — Pogibshi Island, opposite the village of Kadiak, Alaska.

Collectors. — G. K. Gilbert, B. K. Emerson, Charles Palache.

Genus **Myelophycus** gen. nov.

(*Münsteria*, part, Fischer-Ooster.)

As interpreted these supposed marine plants were simple, curved, subcylindrical or claviform masses, consisting of an outer laminated and superficially granulose integument and an inner pith-like portion made up of a succession of conical cups set one into the other.

Besides the type species next described we know of only one other form that we would refer to this genus. This was figured in 1858 by Fischer-Ooster in his paper entitled Die fossilen Fucoiden der Schweizer-Alpen (pl. XVI, fig. 5), and referred by him to *Münsteria hœssii* Sternberg. Comparing this figure with all others at hand of Sternberg's species, we find that it is clearly distinct, the *M. hœssii* of other authors being without the granulose external integument. This outer integument and the invaginated cones of the inner portion distinguish the proposed genus from *Münsteria*, *Keckia*, *Ceratophycus*, *Caulinites* and other genera having a transversely wrinkled surface.

Myelophycus curvatum sp. nov.

Pl. XIII, fig. 2.

The originally cylindrical or club-shaped masses upon which this species is founded are now greatly compressed and cover most of one surface of a slightly arenaceous slab of slate about 8 inches wide and between 12 and 13 inches long. They are from 10 cm. to 15 cm. long, strongly curved, and from 2 cm. to 4 cm. wide, the latter dimension being at one of the extremities, which as a rule is more or less expanded. The average width may be set down at about 3 cm. When the outer integument, which is thick, laminated and superficially rather coarsely granulose, is worn away, the invaginated cones of the inner structure, which takes up about half the width of the entire fossil, are exposed. When the wearing has not materially affected these, then only their straight or accidentally curved edges are seen,

but when the latter are cut away the walls of the vertically sectioned cones present a pinnate arrangement. The texture of the fossils, of whose organic nature we are thoroughly satisfied, is coarser and their color lighter than that of the black slate in which they are embedded.

Compared with *Münsteria hœssii* F.-Ooster (*non* Sternberg), the Swiss Eocene species mentioned under the generic description, *Myelophycus curvatum* is distinguished by its larger size and smaller internal cones.

Locality.—Woody Island, Kadiak, on the shore facing Chiniak Bay, Alaska. The same slab contains the types of *Inoceramya concentrica.*

Collector.—W. H. Dall.

FOSSIL PLANTS FROM KUKAK BAY

FOSSIL PLANTS FROM KUKAK BAY

BY FRANK HALL KNOWLTON

SOMETIME toward the close of 1900 I received through Dr. W. H. Dall, of the U. S. Geological Survey, several small boxes of fossil plants that had been obtained by the Harriman Expedition to Alaska. They were collected, I am informed, by Mr. DeA. Saunders, in Kukak Bay, on the Alaska Peninsula, a little north of west from Kadiak Island. The only information available regarding their occurrence is contained in the following brief note sent me by Mr. Palache: "There was no geologist with the party that found them, and the data concerning them are extremely meager. I have no section showing relations, nor do I know what the attitude of the strata was. With them were coarse conglomerates and grits, said to be interbedded, but I do not know whether above or below; also andesitic lavas which were, I believe, overlying the plant beds."[1]

SYSTEMATIC ENUMERATION OF SPECIES

Family **EQUISETACEÆ**

Equisetum globulosum Lesq.

Equisetum globulosum LESQ., Proc. U. S. Nat. Mus., vol. v, p. 444, pl. VI, figs. 1, 2, 1882.

The collection contains two fragmentary examples that seem to be-

[1] In litt., Jan. 22, 1902. See also page 28.

long to this species. They are a little smaller but otherwise do not differ essentially from the typical form.

Family PINACEÆ

Picea harrimani sp. nov.

Pl. XXII, figs. 3, 4.

Cones cylindrical, long and relatively slender, rounded at apex; scales large, in seventeen or more whorls, about four or five showing in each row, regularly rhomboidal in shape; apparently without marking or obvious thickening.

The specific name is given in honor of Mr. E. H. Harriman, the patron of the Expedition.

This splendid species is represented by four examples, two of which are here figured. The largest of the four (pl. XXII, fig. 4) is preserved for a length of 10 cm. and when perfect was probably fully 12 cm. long. At the base it is 2.5 cm. broad, and it is 2 cm. broad near the apex. The scales in the lower portion are about 11 mm. in length, and 6 or 7 mm. in short diameter. They are slightly smaller in the upper part of the cone.

The smallest example, also figured (pl. XXII, fig. 3), has about 9 cm. of the length preserved, but the base is evidently lacking. It is much narrower than the others, being only 1.5 cm. broad. The scales are smaller, being about 7 mm. in long, and 5 or 6 mm. in short diameter. It is possible that this specimen may represent a different species.

Of the two other examples the best preserved shows only the upper portion. It is of about the same size as the upper portion of the largest one figured. The other is preserved nearly entire but does not show the scales well. It is 7.5 cm. in length and about 2 cm. in width. All of the cones are slightly curved, this last mentioned one in particular.

Of course we are here considering only the impression of the outer portion of the cone, but the actual substance is represented by a coaly mass 1 or 2 mm. in thickness, which has been mostly crumbled away in handling.

It was at first supposed that these were cones of a *Pinus* allied to *P. strobus* L., but after further consideration it appears more probable that they belong to the genus *Picea*. In a general way they are similar to *P. sitchensis* Carr., the Alaska spruce, but are narrower and longer than is usual in this species. The edges of the scales in the

living species incline to be fimbriate or erose, but they appear to be practically entire in the fossil form under consideration.

On some of the pieces of matrix there are numerous detached coniferous leaves, but it is not known whether they belong to this genus.

Picea (branches).

Pl. XXIV, fig. 3; pl. XXV, figs. 3, 4.

The collection contains several branches showing the characteristic leaf-bases of this genus. The finding of cones and branches is thus proof positive of the presence of this group of trees. The leaves have not been detected with certainty, yet there are numerous detached leaves that may well have belonged with these branches.

Picea? (seed).

Pl. XXXIII, fig. 1.

Notwithstanding the abundance of conifers in this collection, only the single seed here figured has been observed. This, as may be seen, is nearly perfect, being 11 mm. in length, with the wing 4 mm. broad. The nuclear portion is about 3 mm. in diameter.

It is practically impossible to distinguish this seed from that of a *Pinus*, but since cones and branches of *Picea* are abundant, and only a few questionable leaves of *Pinus* are present, it seems logical to refer it to the former.

Pinus? (leaves).

Pl. XXIII, fig. 2.

On several pieces of matrix there are numerous detached leaves that in all probability belong to *Pinus*. They are between 4 and 5 cm. in length, about 2 mm. in width and have narrowed, sharp-pointed distal ends. There is, however, no indication of their aggregation into bundles.

Pinus? (scales).

Pl. XXIV, fig. 1.

The collection contains a single piece of matrix on which are preserved what appear to be detached scales of the cone of a *Pinus*. They are of a nearly regular oblong shape, 14 to 17 mm. long and 6 to 9 mm. broad. Occasionally they are a little narrower at one end and very slightly pointed. They were evidently very thick, for the actual substance is represented in places by a heavy coaly layer. There is some evidence of the presence of furrows in which the two seeds were contained, but this is not conclusive.

Sequoia heerii Lesq.

Sequoia heerii LESQ., Tert. Fl., p. 77, pl. VII, fig. 13, 1878.—NEWBERRY, Later Extinct Floras, p. 20, pl. XLVII, fig. 7, 1898.

The collection contains a single globular cone that is not to be distinguished from this species.

Sequoia (cone).

Pl. XXII, fig. 1.

There is a single cone in longitudinal section and still attached to the long, slender peduncle. It is oblong as seen in section, being about 16 mm. long and 15 mm. broad at the base. The peduncle is 3.5 cm. long and a little more than 2 cm. thick above. As nearly as can be made out, about four scales on each side are shown in section.

The long, thick, apparently naked peduncle is the same as that in *Sequoia heerii* and this may belong to that species, but I am not certain from the section through the middle of the cone as to the shape of the scales, and it seems best to consider it as different, at least for the present.

Taxodium distichum miocenum Heer.

Taxodium distichum miocenum HEER, Mioc. Balt. Fl., p. 18, pl. II; pl. III, figs. 6, 7, 1869.

This is by far the most abundant species in the collection, for besides some thirty or forty pieces of matrix containing hardly anything else, there is scarcely a piece that does not bear branchlets of greater or less size.

Taxodium tinajorum Heer.

Taxodium tinajorum HEER, Fl. Foss. Arct., p. 22, pl. I, figs. 1–5, 1869.

There are several specimens that seem to belong to this species, although it is difficult to separate them in all cases from the former species.

Family **JUGLANDACEÆ**

Juglans acuminata Al. Br.

Pl. XXXIII, fig. 3.

Juglans acuminata AL. BR.—HEER, Fl. Foss. Arct., p. 38, pl. IX, fig. 1, 1869.

Hicoria magnifica sp. nov.

Pl. XXVI, fig. 1; pl. XXVII; pl. XXIX, fig. 1.

Leaves evidently of large size, very thick and coriaceous in texture. Terminal leaflets largest, broadly obovate in outline, long wedge-shaped at base, widest at a point two-thirds the length above the base,

whence they are rather abruptly rounded to the obtuse apex; margin obscurely but relatively finely serrate except in the basal portion; midrib very thick, straight; secondaries numerous, about 18 pairs, very strong, alternate, at somewhat irregular distances, arising at an angle of about 45°, slightly curving upward, usually with several craspedodrome branches near the margin, campto-craspedodrome; the secondaries usually arching just at the margin and joining the one next above with small nervilles, numerous, very prominent and deeply marked, mainly once broken though often percurrent and at right angles to the secondaries. Lateral leaflets of various sizes but in general much smaller than the terminal, elliptical-oblong in outline, abruptly rounded and very unequal-sided at base, moderately acuminate at apex; margin and nervation practically the same as in the terminal leaflets.

This fine species is represented by a dozen or more examples, several of which are nearly perfect. The terminal leaflets are from 13 to about 23 cm. long and from 7 to 12 cm. wide, while the lateral leaflets are from about 8 to probably 15 cm. long and from 3.5 to 8.5 cm. wide. These leaflets are mainly detached, but occasionally two or more are found closely associated and overlapping, and in one instance matted together in such a way as to suggest the probability of former union. There are also preserved in association with them objects that look very much like the rachis of a large compound leaf, but there is no actual evidence to show that these leaflets were ever borne on them.

This species would seem to find its nearest relative in *Hicoria* (*Carya*) *antiquora* (Newb.) Kn.[1] That species also has large, coriaceous leaflets, but they differ in shape and in the configuration of the margin, being regularly finely serrate. The nervation is of much the same type.

Family **BETULACEÆ**

Betula (branch).

Pl. XXIV, fig. 2.

The collection contains a single fragment of a branch showing the lenticels characteristic of this genus. The branch was about 1 cm. in diameter.

Corylus macquarrii (Forbes) Heer.

Corylus macquarrii (FORBES) HEER, Urwelt d. Schweiz, p. 321, 1865.

The collection contains a large number of leaves that belong to this well-marked species.

[1] Cf. Lesquereux, Tert. Fl., p. 289, pl. LVII, figs. 1–5, 1878; Newberry, Later Extinct Floras, p. 35, pl. XXXI, figs. 1–4, 1898.

Corylus harrimani sp. nov.

Pl. XXIII, fig. 1.

Leaves of immense size, coriaceous in texture, broadly ovate or elliptical, heart-shaped at base; margin coarsely and irregularly dentate; midrib very strong; secondaries about 9 pairs, very strong, mainly alternate, lowest pair nearly at a right angle, others at an angle of about 45°, all craspedodrome and with several branches on the lower side which also end in marginal teeth; nervilles numerous, very strong, percurrent, at right angles to the secondaries; finer nervation producing large areolæ.

The specific name is given in honor of Mr. E. H. Harriman, the patron of the Expedition.

This splendid species is represented by the nearly perfect example figured and by a few fragments. This specimen is rather elliptical-cordate in shape, being 20 cm. in length and about 17 cm. in width. It is well shown by the figure.

That this leaf belongs to *Corylus* seems certain. It is much the same in appearance as certain leaves referred to *C. macquarrii*, but it is of nearly four times the size of the leaves of that species and moreover differs in certain details. In general appearance it perhaps approaches closest to *C. scottii* Heer,[1] from Spitzbergen, but it is twice as large and differs in shape. The marginal dentition is, however, much the same.

Corylus? palachei sp. nov.

Pl. XXII, fig. 2; pl. XXVIII, fig. 1.

Leaves in general of small size, coriaceous, ovate or ovate-oblong, truncate or very slightly heart-shaped at base, rather obtuse at apex; margin coarsely and unequally toothed, the teeth sharp and almost spiny pointed; midrib strong, straight or slightly flexuose; secondaries thin, 7 or 8 pairs, basal ones at a low angle, others at an angle of about 45°, craspedodrome, often with two or three short branches which end in teeth; nervilles numerous, mainly percurrent.

The specific name is given in honor of Dr. Charles Palache, one of the geologists of the Expedition.

This species is represented by a considerable number of specimens, all of which agree closely. They are about 5 cm. in length and 4 cm. in width.

I am somewhat uncertain as to the genus to which these leaves should be referred. They appear to be the same as certain leaves from

[1] Fl. Foss. Arct., vol. IV, Abth. 1, p. 73, pl. XXIX, fig. 1, 1876.

Spitzbergen referred by Heer to *Ulmus braunii*,[1] but it seems impossible that they should belong to this genus. They do not altogether agree with *Corylus*, yet seem perhaps closer to this than to any other. For the present they may remain under this name.

Alnus corylifolia Lesq.

Alnus corylifolia LESQ., Proc. U. S. Nat. Mus., vol. v, p. 446, pl. VII, figs. 1–4, 1882.

The collection contains several perfect and beautifully preserved leaves, as well as a number of broken examples, that appear to belong to this species. They are of about the same size as the leaves in figs. 2 and 3 (loc. cit.); they have rather finer teeth, but otherwise do not differ essentially.

Alnus sp.

Pl. XXVIII, fig. 2; pl. XXXIII, fig. 4.

The collection contains two specimens that appear to represent the female catkins of an alder. They are well shown in the figures.

Family **ULMACEÆ**

Ulmus braunii Heer.

Ulmus braunii HEER, Fl. Tert. Helv., vol. II, p. 59, pl. LXXIX, figs. 14–21, 1856.—LESQUEREUX, Cret. & Tert. Fl., p. 161, pl. XXVII, figs. 1–4, 1883.

I have some doubt as to the correctness of referring these leaves to *Ulmus*, but the examples in hand are not to be distinguished from certain specimens from Spitzbergen and other localities that have been so referred by Heer,[2] and I have thus regarded them.

Family **ACERACEÆ**

Acer trilobatum var.

Pl. XXIX, fig. 2.

The collection contains several broken leaves of a maple, one of the best being figured. This appears to be one of the forms of the variable *A. trilobatum*. It lacks the upper portion, and its position, therefore, can not be definitely fixed.

Family **HIPPOCASTANACEÆ**

Æsculus arctica sp. nov.

Pl. XXX.

Leaflets of large size, coriaceous, obovate-lanceolate, rather abruptly rounded to an obtusely acuminate apex; margin entire below, finely

[1] Fl. Foss. Arct., vol. IV, Abth. I, pl. XVI, figs. 5–8, 1876.

[2] Fl. Foss. Arct., vol. IV, Abth. I, p. 75, pl. XVI, figs. 3, 4, 1876.

serrate above; midrib very thick and strong; secondaries very numerous, 25–30 pairs, thin, mostly alternate, those in the lower, narrower basal portion being often at a slight angle, those above arising nearly at an angle of 45°, running nearly or quite straight to within 13 mm. of the margin, then turning abruptly upward to end in a marginal tooth; secondaries often with two or three slight branches very near the margin, which pass to marginal teeth; nervilles numerous, strong, both broken and percurrent; finer nervation not clearly preserved.

A number of examples, some of them nearly perfect, represent this species. They all seem to be of about the same size. The nearly perfect leaflet figured is 20 cm. in length and about 9 cm. in width. It is well shown in the figure.

Family **STERCULIACEÆ**

Pterospermites magnifolia sp. nov.

Pl. XXXI.

Leaves very large, coriaceous, ovate-cordate, obtusely acuminate at apex; margin coarsely and irregularly toothed, the teeth low and obtuse; midrib very strong, straight; secondaries strong, about 14 pairs, mostly alternate, those at the base clustered, emerging at a right angle or falling below one, those above at an angle of about 45°, slightly curved upward, craspedodrome, ending in the large marginal teeth; nervilles numerous, strong, mainly percurrent and at right angles to the secondaries; finer nervation obscure.

This species is represented by the largest leaves in the collection, the figured example being 23 cm. in length and about 14 cm. in width. Other specimens are 20 cm. long and 14 cm. wide, and there are fragments that would seem to indicate a still larger size.

Pterospermites alaskana sp. nov.

Pl. XXVI, fig. 2; pl. XXXII.

Leaves of large or medium size, thick, coriaceous, ovate or ovate-oblong, obtusely wedge-shaped or rounded at base, obtuse at apex; margin coarsely dentate, the teeth somewhat irregular, very flat and obtuse at the point; petiole strong; midrib rather thin for the size of the blade, perfectly straight; secondaries 11 or 12 pairs, thin, alternate, at an angle of about 45°, little if any curved upward, craspedodrome, ending in the large marginal teeth, occasionally with one or two short branches on the lower side near the margin; nervilles moderately numerous, usually broken, though often percurrent but curved on crossing; finer nervation obscure.

This species is represented by several nearly perfect examples as well as by numerous fragments of greater or less size. The largest example (see pl. XXXII) is 15.5 cm. in length and 10 cm. in width. The widest point being in the middle of the blade. The smallest specimen (pl. XXVI, fig. 2) is about 12 cm. in length and 7.5 cm. in width.

This species is certainly very closely allied to the preceding, and it is possible that only a single species is represented. This appears to differ, however, in being uniformly of much smaller size and in being wedge-shaped at base instead of distinctly heart-shaped. The marginal teeth and the nervation are similar in both, except that midrib and secondaries are relatively lighter in *P. alaskana*.

Family ERICACEÆ

Andromeda grayana Heer.

Andromeda grayana HEER, Neue Deukschr. d. Algem. Schw. Gesell., vol. XXI, p. 7, pl. I, figs. 7–9, 1865.

Vaccinium alaskanum sp. nov.

Pl. XXV, fig. 1.

Leaf coriaceous, obovate-oblong, abruptly narrowed at base, obtuse at apex; margin entire below, finely but obscurely serrate in the upper portion; midrib strong below, much more slender above; secondaries thin, about eight pairs, opposite below, alternate in the upper part of the blade, at an acute angle, much curving upward, craspedodrome, each joining the secondary next above; intermediate secondaries several; nervilles numerous, thin, both percurrent and broken, approximately at right angles to the midrib; finer nervation producing minute areas.

The single figured example is all that was contained in this collection. It is a small leaf, oblong, slightly obovate, and 4.25 cm. long by 1.5 cm. in width.

This leaf is apparently not closely allied to any previously described from Alaska.

Phyllites saundersi sp. nov.

Pl. XXV, fig. 2; Pl. XXXIII, fig. 2.

The collection contains about a dozen fragments, two of which are here figured. I am uncertain as to the exact nature of these little objects. At first sight certain of the detached specimens have the appearance of being catkins of something like *Salix* or *Populus*, but, as

may be seen in the figures, they stand erect on short, thick branches, quite unlike the conditions obtaining in either of these genera. It may be that they are the branches of a conifer beset with numerous thick leaves, but neither do they meet all the requirements necessary for such a reference. I can only figure them and place them under this anomalous generic aggregation until additional light or further collections may be obtained. It is quite possible that they may not all belong to the same form.

The species is named in honor of Mr. De Alton Saunders, by whom the collection of fossil plants was made.

DISCUSSION OF THE FLORA

The study of any fossil flora naturally possesses interest along two lines, the biological and the geological. Careful biological study is necessary in order that the forms under investigation may be relegated as nearly as possible to their proper position in the vegetable kingdom, and moreover, it may throw important light on the phylogeny of existing types. The geological study throws light on the age of the beds in which the flora is contained, and serves also to furnish a set of stratigraphic marks for the identification of similar horizons in other areas.

BIOLOGICAL ASPECT

For purposes of comparison and ready reference the following complete list of forms, disposed under families, is presented:

I. EQUISETACEÆ.

1. *Equisetum globulosum* Lesq.

II. PINACEÆ.

2. *Picea harrimani* sp. nov.
3. *Picea*, branches.
4. *Picea ?*, seed.
5. *Pinus ?*, leaves.
6. *Pinus ?*, scales of cone.
7. *Sequoia heerii* Lesq.
8. *Sequoia*, cone.

9. *Taxodium distichum miocenum* Heer.
10. *Taxodium tinajorum* Heer.

III. Juglandaceæ.

11. *Juglans acuminata* Al. Br.
12. *Hicoria magnifica* sp. nov.

IV. Betulaceæ.

13. *Betula*, branch.
14. *Corylus macquarrii* (Forbes) Heer.
15. *Corylus harrimani* sp. nov.
16. *Corylus? palachei* sp. nov.
17. *Alnus corylifolia* Lesq.
18. *Alnus* sp.

V. Ulmaceæ.

19. *Ulmus braunii* Heer.

VI. Aceraceæ.

20. *Acer trilobatum* var.

VII. Hippocastanaceæ.

21. *Æsculus arctica* sp. nov.

VIII. Sterculiaceæ.

22. *Pterospermites magnifolia* sp. nov.
23. *Pterospermites alaskana* sp. nov.

IX. Ericaceæ.

24. *Andromeda grayana* Heer.
25. *Vaccinium alaskanum* sp. nov.

X. Insertæ Sedis.

26. *Phyllites saundersi* sp. nov.

From this it appears that nine families and twenty-six forms are represented. Of these families the richest, both in forms and individuals, is the Pinaceæ, to which nine forms are referred. The most abundant conifer is *Taxodium distichum miocenum*, which is represented by forty or more pieces of matrix on which there is nothing else preserved, while hardly a piece in the collection is without fragments of greater or less size. The species must have been an important element in this flora, as it undoubtedly was in other arctic floras. Associated with it,

but probably in less abundance, was the species described as *Picea harrimani*, which is quite closely allied to the *P. sitchensis* now living in the region. There are branches which undoubtedly belong to a spruce, and a single seed which in all probability also belonged to a *Picea*. Scattered over many pieces of matrix are numerous short, thick coniferous leaves which may well have belonged to this species of *Picea*. The genus *Pinus* is more or less uncertain, but is apparently represented by several detached leaves 5 cm. or more in length, and scales that appear to represent a broken pine cone. *Sequoia* evidently did not have a very prominent place in the flora, as it is represented only by a single cone that is referred to *S. heerii* of Lesquereux, and a much broken cone that may or may not be of the same species. The few branchlets referred to *Taxodium tinajorum* are hardly to be distinguished from *T. distichum miocenum* and may be only more robust examples of the latter.

The next most conspicuous family, in point of species as well as individuals, is the Betulaceæ. *Betula* itself is represented by a small but unmistakable fragment of the bark which shows the well-known lenticels. The most abundant dicotyledon in the collection is *Corylus macquarrii*, which is represented by leaves and fragments. Of the two species of *Corylus* described as new, *C. harrimani* must have been a magnificent tree, with leaves 20 cm. in length and 17 cm. in width. Judging simply from the present collection, this was not a very abundant species. The somewhat anomalous leaves described as *Corylus? palachei* may or may not belong to this genus. The remaining members of the Betulaceæ are two forms of *Alnus*, one of which (*A. corylifolia*) is represented by a considerable number of small, sharply serrate leaves.

The Juglandaceæ are represented by a single species each of *Juglans* and *Hicoria*, the latter being a truly

magnificent form, with leaflets from 8 to 23 cm. in length. It finds its greatest affinity with *H. antiquora* of the lower Tertiary of the United States.

The Ulmaceæ are represented by several leaves that are referred to *Ulmus braunii* of Heer, though not without some hesitation.

That the family Aceraceæ was present is shown by a number of more or less broken leaves that have been referred to *Acer trilobatum* var. They are too fragmentary to venture a positive identification.

GEOLOGICAL ASPECT

Of the twenty-six forms represented in the collection nine are described as new to science, seven are not named specifically, being branchlets, seeds, scales, broken cones, etc., thus leaving ten species previously known. These are as follows:

Equisetum globulosum Lesq.
Sequoia heerii Lesq.
Taxodium distichum miocenum Heer.
Taxodium tinajorum Heer.
Juglans acuminata Al. Br.
Corylus macquarrii (Forbes) Heer.
Alnus corylifolia Lesq.
Ulmus braunii Heer.
Acer trilobatum var.
Andromeda grayana Heer.

Equisetum globulosum was described originally from Cook Inlet, Alaska, and was also detected by Lesquereux in Fort Union beds near the mouth of the Yellowstone River. *Sequoia heerii* was first found at Sage Creek (?), Montana, in beds of doubtful Green River age. It has since been found in the Upper Clarno formation (Upper Eocene) at Bridge Creek, Oregon, and is now for the first time reported from Alaska. *Taxodium distichum miocenum* enjoys a very wide distribution, but is especially

abundant in arctic lands. Every collection from Alaska contains numerous examples of this species. The closely allied *T. tinajorum* was described originally from Port Graham, Alaska. *Juglans acuminata* was found by Heer at Port Graham also, though first described from the European Miocene. *Corylus macquarrii* has quite a wide distribution, but is especially abundant in Alaska. It has also been reported from the Fort Union beds of Montana and British Columbia, and doubtfully from the Laramie. *Alnus corylifolia* has been reported from Cook Inlet. *Ulmus braunii*, described from the Swiss Miocene originally, has been reported from Kamloops, British Columbia, in strata of probable Eocene age, and from the Green River beds at Florissant, Colorado. *Acer trilobatum*, as already pointed out, is too poorly preserved to admit of full identification. A form of this species has been found at Herendeen Bay, but it is not possible to say that they are identical. *Andromeda grayana* was originally made known from Port Graham, Alaska, but has since been rather doubtfully identified from one or two other localities.

From this hasty review it appears that four of the ten species have never been found outside of Alaska, while the remainder are abundantly characteristic of the same region.

It is hardly necessary at this time to go into a history of the plant-bearing horizons of Alaska, as this has been fully done in my Review of the Fossil Flora of Alaska.[1] It is sufficient to state that the named species above enumerated are typical of the so-called 'Arctic Miocene,' which is now regarded as of the age of the Upper Eocene. The species described in this paper as new are in various ways allied to forms characterizing this horizon, and I do not hesitate to refer this collection to the Upper Eocene.

[1] Proc. U. S. Nat. Mus., vol. XVII, pp. 207–240, Pl. IX, 1894.

EXPLANATION OF PLATE XXII

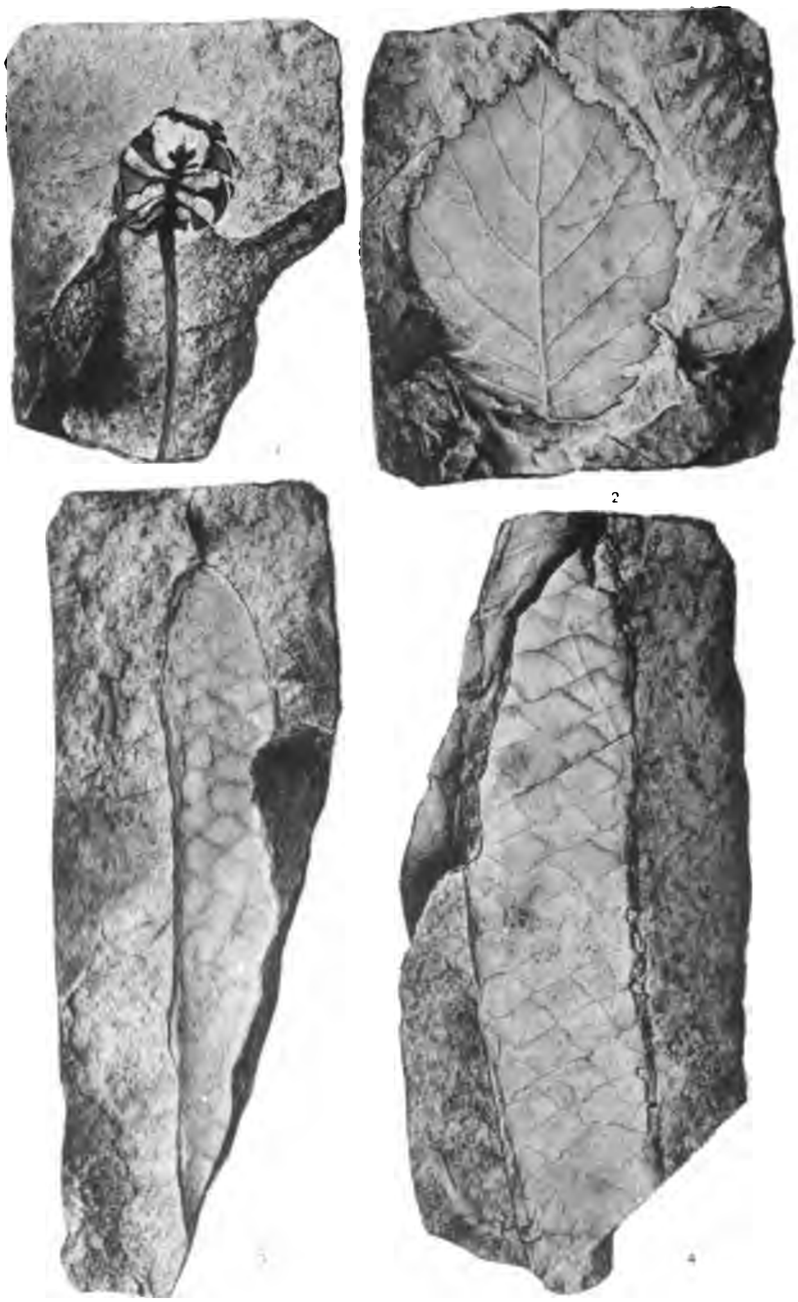
Eocene of Kukak Bay, Alaska Peninsula

Natural size

Fig. 1. *Sequoia* sp. Cone, in section. See page 154.

2. *Corylus ? palachei* sp. nov. Leaf. See page 156 and plate XXVIII.
3. *Picea harrimani* sp. nov. Impression of cone. See page 152.
4. *Picea harrimani* sp. nov. Cone.

[Note.—Copy for plates XXII to XXXIII was prepared with the aid of photography, as follows: The specimens were first given a uniform gray color, by the Williams process, and then photographed. Thus made, the photographs expressed only the forms of the specimens, without complication from differences of local color. They were afterward treated by a draftsman, who, guided by the specimens, strengthened outlines and other important features. G. K. G.]



EOCENE, ALASKA PENINSULA

1 SEQUOIA 2 CORYLUS? 3, 4 PICEA

HELIOTYPE CO., BOSTON.

EXPLANATION OF PLATE XXIII

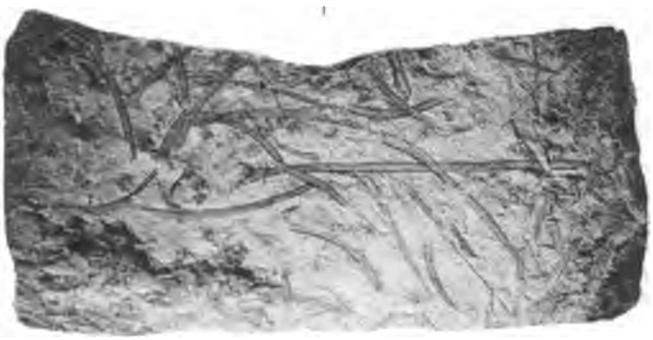
EOCENE OF KUKAK BAY, ALASKA PENINSULA

Three-fifths natural size

FIG. 1. *Corylus harrimani* sp. nov. Under side of leaf. See page 156.

2. *Pinus ?* Leaves. See page 153.

1



2

EOCENE, ALASKA PENINSULA

1 CORYLUS 2 PINUS?

HELIOTYPE CO., BOSTON.

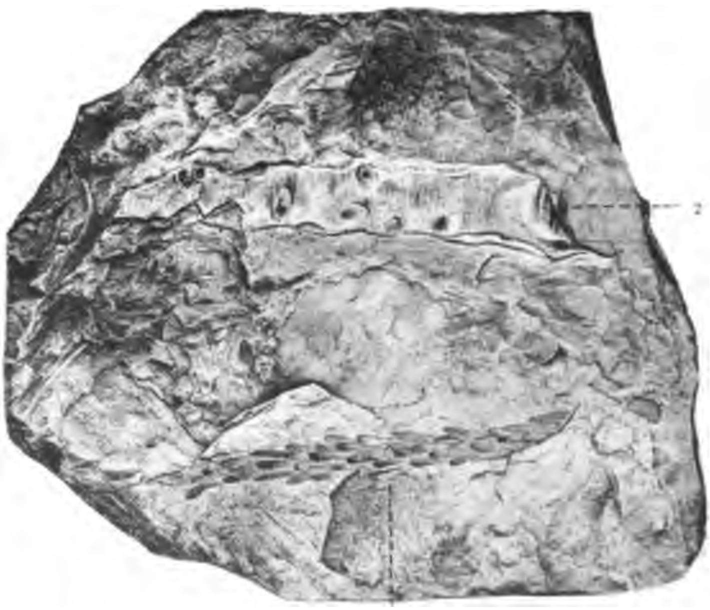
EXPLANATION OF PLATE XXIV

EOCENE OF KUKAK BAY, ALASKA PENINSULA

Natural size

FIG. 1. *Pinus ?* Scales of cone. See page 153.
2. *Betula* sp. Branch. See page 155.
3. *Picea* sp. Branch. See page 153, and plate xxv.

1



3

EOCENE, ALASKA PENINSULA

1 PINUS? 2 BETULA 3 PICEA

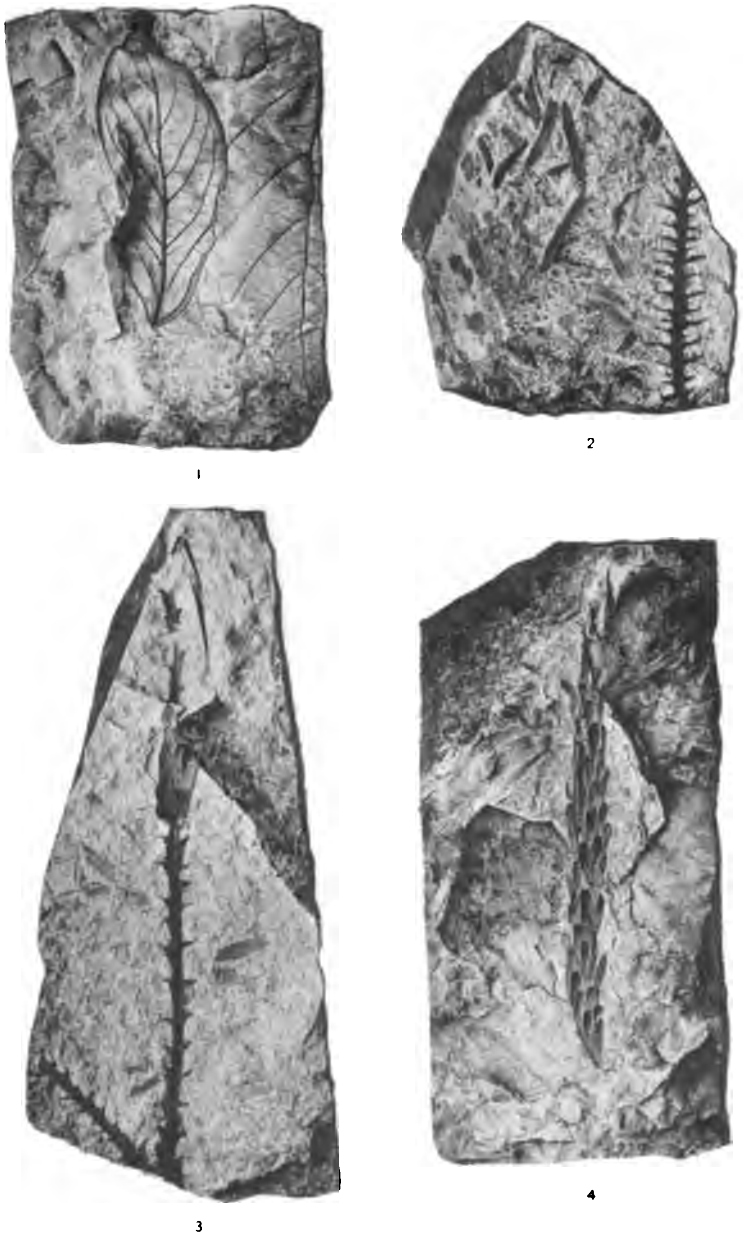
HELIOTYPE CO., BOSTON.

EXPLANATION OF PLATE XXV

EOCENE OF KUKAK BAY, ALASKA PENINSULA

Natural size

FIG. 1. *Vaccinium alaskanum* sp. nov. Leaf. See page 159.
2. *Phyllites saundersi* sp. nov. See page 159, and plate XXXIII.
3 and 4. *Picea*. Branches. See page 153, and plate XXIV.



EOCENE, ALASKA PENINSULA

1 VACCINIUM 2 PHYLLITES 3, 4 PICEA

HELIOTYPE CO., BOSTON.

EXPLANATION OF PLATE XXVI

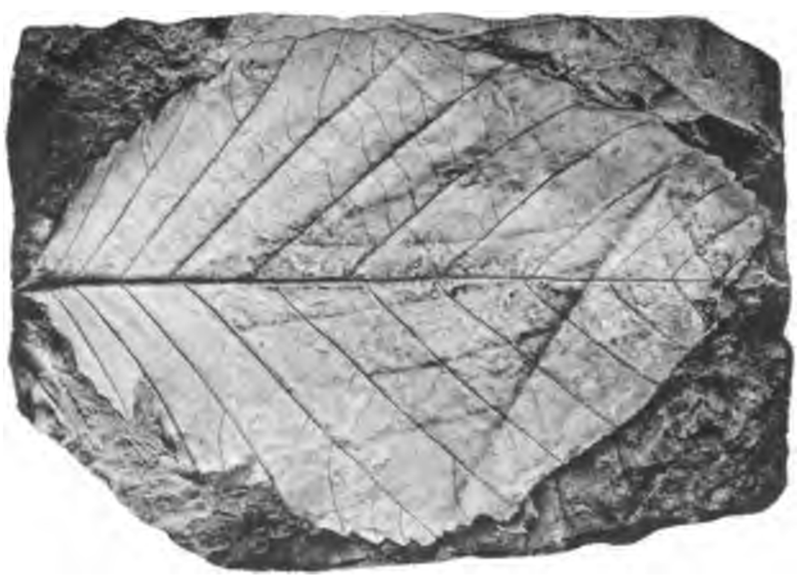
Eocene of Kukak Bay, Alaska Peninsula

Natural size

Fig. 1. ***Hicoria magnifica*** **sp. nov. Lateral leaflet; under side.** **See page 154, and plates XXVII and XXIX.**

2. ***Pterospermites alaskana*** **sp. nov. Upper side of leaf. See page 158, and plate XXXII.**

1



2

EOCENE, ALASKA PENINSULA

1 HICORIA 2 PTEROSPERMITES

HELIOTYPE CO., BOSTON.

EXPLANATION OF PLATE XXVII

EOCENE OF KUKAK BAY, ALASKA PENINSULA

Three-fourths natural size

Hicoria magnifica sp. nov. Terminal leaflet; impression of under surface. See page 154, and plates XXVI and XXIX.

EOCENE, ALASKA PENINSULA

HICORIA MAGNIFICA sp. nov.

HELIOTYPE CO., BOSTON.

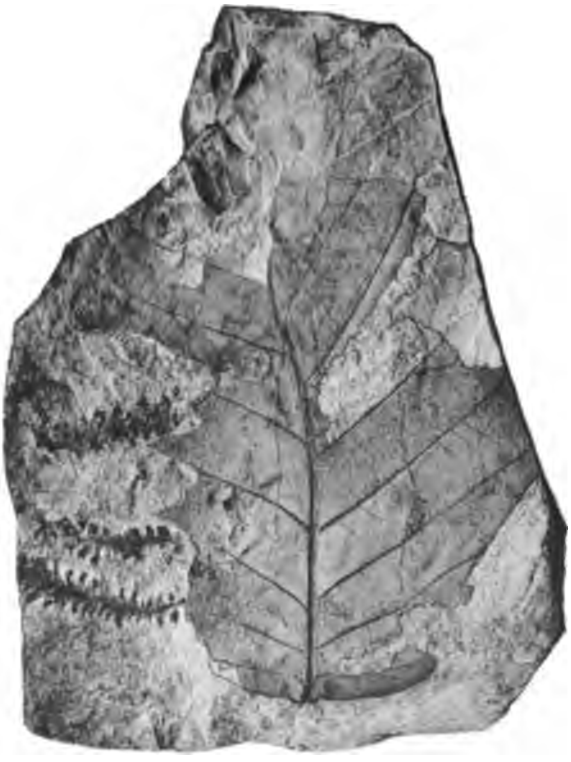
EXPLANATION OF PLATE XXVIII

EOCENE OF KUKAK BAY, ALASKA PENINSULA

Natural size

FIG. 1. *Corylus ? palachei* sp. nov. See page 156 and plate XXII.
2. *Alnus* sp. Catkins. See page 157, and plate XXXIII.

1



2

EOCENE, ALASKA PENINSULA

1 CORYLUS? PALACHEI sp. nov. 2 ALNUS sp.

HELIOTYPE CO., BOSTON.

EXPLANATION OF PLATE XXIX

EOCENE OF KUKAK BAY, ALASKA PENINSULA

Natural size

FIG. 1. *Hicoria magnifica* sp. nov. Lateral leaflet. See page 154, and plates XXVI and XXVII.

2. *Acer trilobatum* var. See page 157.

1

2

EOCENE, ALASKA PENINSULA

1 HICORIA MAGNIFICA sp. nov. 2 ACER TRILOBATUM var.

HELIOTYPE CO., BOSTON.

EXPLANATION OF PLATE XXX

EOCENE OF KUKAK BAY, ALASKA PENINSULA

Natural size

Æsculus arctica sp. nov. Leaflet; upper side. See page 157.

EOCENE, ALASKA PENINSULA

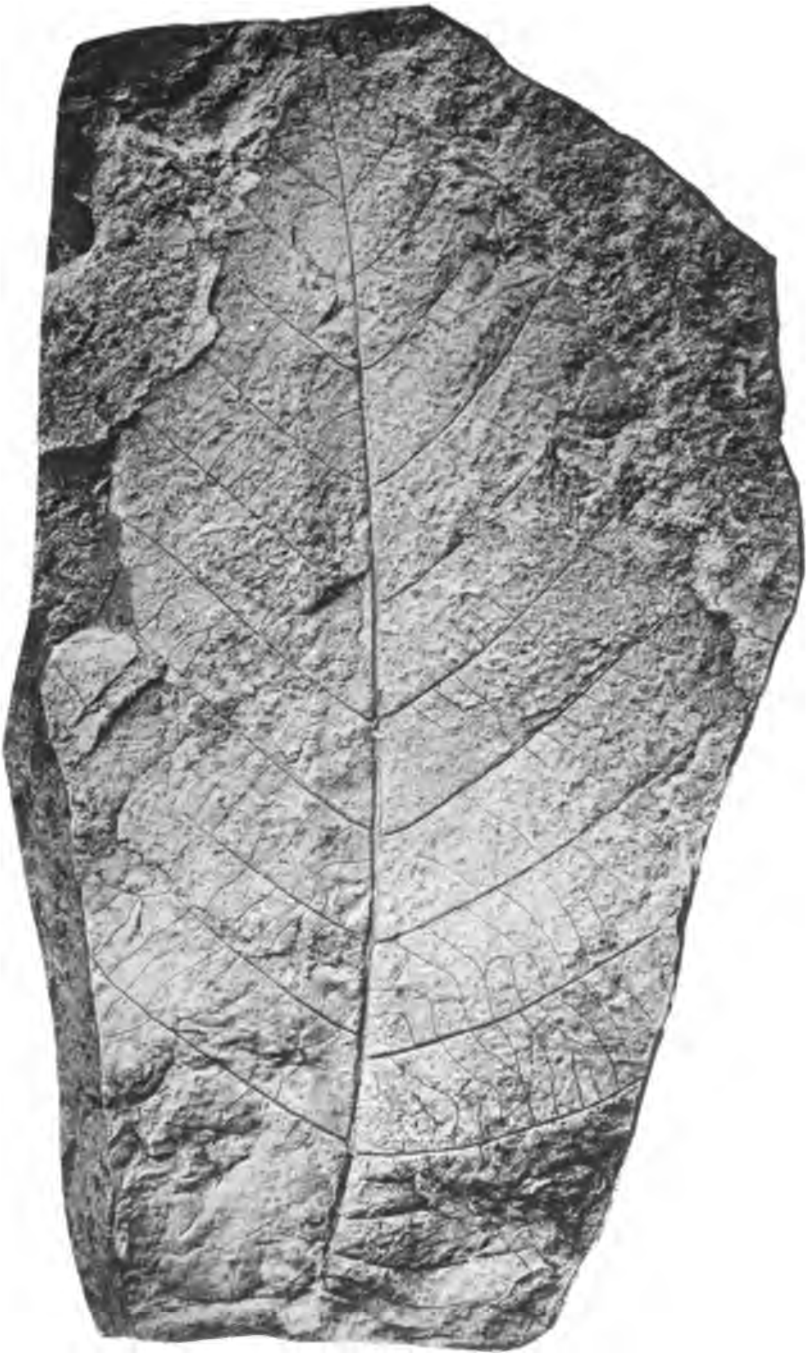
ÆSCULUS ARCTICA sp. nov.

HELIOTYPE CO., BOSTON.

EXPLANATION OF PLATE XXXI

Eocene of Kukak Bay, Alaska Peninsula

Pterospermites magnifolia sp. nov. Upper side of leaf. See page 158.



EOCENE, ALASKA PENINSULA

PTEROSPERMITES MAGNIFOLIA sp. nov.

HELIOTYPE CO., BOSTON.

EXPLANATION OF PLATE XXXII

EOCENE OF KUKAK BAY, ALASKA PENINSULA

Natural size

Pterospermites alaskana **sp. nov. Under side of leaf.** **See page 158, and plate XXVI.**

EOCENE, ALASKA PENINSULA

PTEROSPERMITES ALASKANA sp. nov.

HELIOTYPE CO., BOSTON.

EXPLANATION OF PLATE XXXIII

EOCENE OF KUKAK BAY, ALASKA PENINSULA

Natural size

FIG. 1. *Picea ?*. Seed. See page 153.

2. *Phyllites saundersi* sp. nov. See page 159, and plate XXV

3. *Juglans acuminata* Al. Br. Leaflet. See page 154.

4. *Alnus* sp. Catkins. See page 157, and plate XXVIII.

1

2

3

4

EOCENE, ALASKA PENINSULA

1 PICEA 2 PHYLLITES 3 JUGLANS 4 ALNUS

HELIOTYPE CO., BOSTON.

INDEX

New genera and species of fossils are in **black-face** type; synonyms are in *italics;* pages on which generic or specific descriptions occur are in **black-face** type.

Pages on which rocks receive petrographic description or minerals crystallographic description are in **black-face** type.

DATE DUE

MAY 10 1973				